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AUTHORITY
AFML ltr, 1 Sep 1970

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AD 813037

AIR FORCE MACHINABILITY DATA CENTER (AFMDC)

DISTRIBUTION LIST
"SECOND ANNUAL REPORT" (AFMDC 66-4)

THIS "SECOND ANNUAL REPORT" IS BEING SENT TO YOU TO PROVIDE INCREASED AWARENESS OF THE ACTIVITIES OF AFMDC. FACTS CONCERNING THE CENTER'S OPERATIONS ARE PRESENTED IN INDIVIDUAL CHARTS. AFMDC PROCESSED 736 INQUIRIES DURING THE PAST YEAR (SEE FIGURE 15, P. 19; FIGURE 16, PP. 20-22; AND FIGURE 17, P. 23). DATA PRODUCTS ON BERYLLIUM, GRINDING RATIOS, AND NUMERICAL CONTROL DATA ON 7 OPERATIONS AND 11 MATERIAL GROUPS WERE PRINTED DURING OUR SECOND YEAR OF OPERATION, SEE FIGURE 26, PAGE 38.

IT IS SUGGESTED THAT YOU REVIEW OUR "SECOND ANNUAL REPORT" TO BE CERTAIN THAT YOUR ORGANIZATION IS TAKING FULL ADVANTAGE OF THE SERVICES AVAILABLE. THE ENCLOSED PINK CARD WILL EXPLAIN WHAT IS REQUIRED IN ORDER TO MAKE USE OF AFMDC.

SINCE COPIES OF THIS REPORT ARE LIMITED, WE SUGGEST YOU CONSIDER CIRCULATING OUR ANNUAL REPORT WITHIN YOUR ORGANIZATION SO THAT APPROPRIATE PERSONNEL MAY BE APPRIZED OF AFMDC ACTIVITIES.

YOUR SUGGESTIONS AND COMMENTS ARE INVITED. PLEASE SEND THEM TO:

Air Force Machinability Data Center
3980 Rosslyn Drive
Cincinnati, Ohio 45298
Attn: Mr. John Maranchik, Jr.
Director

TO REQUEST MACHINING INFORMATION

TELEPHONE 513-271-9510
TWX 810-461-2840 or
WRITE AIR FORCE MACHINABILITY DATA CENTER
3980 ROSSLYN DRIVE
CINCINNATI, OHIO 45209

INQUIRIES SHOULD BE DIRECTED TO ONE OF THE FOLLOWING *Machining Data Analysts*:

ROBERT E. SNIDER
ROY L. WILLIAMS
CLARENCE L. MEHL

or

JOHN MARANCHIK, JR.
Director

TO HELP US ANSWER YOUR INQUIRY, IF POSSIBLE PLEASE:

1. IDENTIFY THE MATERIAL BEING MACHINED (specification or trade name); CONDITION (as cast, hot rolled, cold drawn, annealed, quenched & tempered, etc.); MICROSTRUCTURE AND HARDNESS.
2. IDENTIFY THE MATERIAL REMOVAL OPERATION IN QUESTION (turning, milling, drilling, tapping, surface grinding, electrical discharge machining (EDM), electrochemical machining (ECM), etc.).
3. SPECIFY REASONS FOR REQUIRING DATA UNLESS YOUR NEEDS ARE PROPRIETARY. THIS ENABLES AFMDC TO BROADEN THE SCOPE OF ITS TECHNICAL ADVICE.
4. SPECIFY DELIVERY REQUIREMENTS.
5. INDICATE TO WHOM THE INQUIRY REPLY SHOULD BE SENT.
6. TRANSMIT ALL DETAILS CONCERNING PRESENT PRACTICES (including feeds, speeds, cutting tool material and geometry, cutting fluids, etc.) IN THE EVENT YOUR INQUIRY PERTAINS TO IMPROVEMENT OF AN EXISTING MACHINING SITUATION.

NOTE: Association of the names of companies and individuals with specific requests is kept confidential. However, data developed remain the property of AFMDC for dissemination as required for answering similar inquiries and for developing data products.

* * * *

**Best
Available
Copy**

AIR FORCE MACHINABILITY DATA CENTER

3980 ROSSLYN DRIVE CINCINNATI, OHIO 45209
TELEPHONE 513-271-9510 TWX 810-461-2840

SCOPE

THE AIR FORCE MACHINABILITY DATA CENTER (AFMDC) COLLECTS, EVALUATES, STORES, AND DISSEMINATES MATERIAL REMOVAL INFORMATION INCLUDING SPECIFIC AND DETAILED MACHINING DATA FOR THE BENEFIT OF INDUSTRY AND GOVERNMENT. STRONG EMPHASIS IS GIVEN TO ENGINEERING EVALUATION FOR THE PURPOSE OF DEVELOPING OPTIMIZED MATERIAL REMOVAL PARAMETERS, SUCH AS SPEEDS, FEEDS, DEPTHS OF CUT, TOOL MATERIAL AND GEOMETRY, CUTTING FLUIDS AND OTHER SIGNIFICANT VARIABLES. DATA ARE BEING PROCESSED FOR ALL TYPES OF MATERIALS AND FOR ALL KINDS OF MATERIAL REMOVAL OPERATIONS SUCH AS TURNING, MILLING, DRILLING, TAPPING, GRINDING, ELECTRICAL DISCHARGE MACHINING, ELECTRO-CHEMICAL MACHINING, ETC.

STORAGE AND RETRIEVAL

AFMDC HAS A MECHANIZED SYSTEM IN WHICH PUNCH CARDS ARE USED TO STORE AND RETRIEVE ALL TYPES OF MATERIAL REMOVAL INFORMATION INCLUDING ALL SIGNIFICANT NUMERICAL DATA. AN IBM 1130 COMPUTING SYSTEM IS BEING USED FOR STORING AND PROCESSING DATA FROM A MASTER CARD AND DISK FILE AND FOR COMPUTER DECODING. THE FOCAL CONCEPT FOR ACQUISITION, INTERROGATION, OR PRESENTATION OF INFORMATION IS THE SPECIFIC MATERIAL (WITH DEFINITE CHEMICAL, PHYSICAL, AND MECHANICAL PROPERTIES) AND THE SPECIFIC MATERIAL REMOVAL OPERATION BEING USED. WHEN NECESSARY, CARD SOURCE CONTROL CODES MAY BE USED TO RETRIEVE ORIGINAL DOCUMENTS WHICH ARE IN DOCUMENT STORAGE AT AFMDC.

INFORMATION SERVICES

AFMDC PLACES STRONG EMPHASIS ON PROVIDING SPECIFIC AND DETAILED ANSWERS TO TECHNICAL INQUIRIES IN THE FIELD OF MATERIAL REMOVAL. A USER FILE, CONSISTING OF IMPORTANT USERS IN THE FIELD OF MATERIAL REMOVAL, HAS BEEN DEVELOPED TO RECEIVE INFORMATION PRODUCTS INCLUDING MACHINING DATA PAMPHLETS AND TABLES ON MATERIALS OF CURRENT INTEREST, STATE-OF-THE-ART REPORTS, TECHNICAL ANNOUNCEMENTS, AND OTHER APPROPRIATE ITEMS. SERVICES ARE AVAILABLE WITHOUT CHARGE TO THE AEROSPACE INDUSTRY, DEPARTMENT OF DEFENSE (INCLUDING ALL OF THE MILITARY SERVICES AND THEIR CONTRACTORS), AND OTHER GOVERNMENT AGENCIES, TECHNICAL INSTITUTIONS, AND NON-MILITARY INDUSTRIES IN A POSITION TO ASSIST THE DEFENSE EFFORT.

* * * * *

*Operated for the AIR FORCE MATERIALS LABORATORY,
MANUFACTURING TECHNOLOGY DIVISION under
CONTRACT AF 33(615)-5262
by METCUT RESEARCH ASSOCIATES INC.*

**SECOND ANNUAL REPORT OF THE
AIR FORCE MACHINABILITY DATA CENTER**

John Maranchik, Jr.
Metcut Research Associates Inc.

FEBRUARY 1967

Advanced Fabrication Techniques Branch
Manufacturing Technology Division
Air Force Materials Laboratory
Research and Technology Division
Air Force Systems Command
United States Air Force
Wright-Patterson Air Force Base, Ohio

THIS DOCUMENT IS SUBJECT TO SPECIAL EXPORT CONTROLS AND EACH TRANSMITTAL TO FOREIGN GOVERNMENTS OR FOREIGN NATIONALS MAY BE MADE ONLY WITH PRIOR APPROVAL OF THE MANUFACTURING TECHNOLOGY DIVISION.

FOREWORD

This Second Annual Report of the Air Force Machinability Data Center (AFMDC) covers work performed under Contract AF 33(615)-5262 from February 1, 1966 through January 31, 1967. The manuscript was released by the author in February 1967 for publication as an AFMDC report.

This contract with Metcut Research Associates Inc., Cincinnati, Ohio, was initiated under Manufacturing Technology Division Project 9-700, "Air Force Machinability Data Center". It is an extension of Manufacturing Technology Division Project 8-239 as indicated in our First Annual Report. The current contract is being performed under the technical direction of Mr. Max A. Guenther of the Advanced Fabrication Techniques Branch (MATF), Manufacturing Technology Division, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio.

This project is being accomplished as a part of the Air Force Manufacturing Methods Program. The primary objective of AFMDC is to be highly specialized in the collection, evaluation, storage, retrieval and dissemination of significant data and information pertaining to all aspects of material removal processes. Recipients of these data include aerospace industry, Department of Defense (including all of the military services and their contractors), and other Government agencies, technical institutions, and nonmilitary industries in a position to assist the defense effort. In the area of material removal activity, this Center serves as the communications link for the entire technical community, both Government and industry.

Your comments are solicited on the potential utilization of the Air Force Machinability Data Center as applied to your present or future production programs.

This report has been reviewed and is approved.

Melvin E. Fields

MELVIN E. FIELDS, Colonel USAF
Chief, Manufacturing Technology Division
Air Force Materials Laboratory

ABSTRACT

SECOND ANNUAL REPORT OF THE AIR FORCE MACHINABILITY DATA CENTER

John Maranchik, Jr.

This is the Second Annual Report of the Air Force Machinability Data Center covering the period February 1, 1966 through January 31, 1967 (Contract AF 33(615)-5262). Eight thousand eight hundred and sixty (8,860) documents were processed and 46,428 machining situations were evaluated and placed in data storage. Seven hundred thirty-six (736) specific inquiries were answered for 396 different companies in 90 different SIC categories. Thirteen thousand seven hundred and six (13,706) copies of 11 different data products were distributed during this period.

The average cost of inquiries equalled \$45.02 per inquiry.

An IBM 1130 computer system was installed and made available to AFMDC on July 1, 1966. Computer programs were written to store, update and search the files necessary to operate the Center.

PREFACE

This report covers a 12-month period of operation from February 1, 1966 through January 31, 1967. It is presented primarily in the form of individual charts which are self-explanatory with regard to organization of the Center and the results of its efforts including costs. For each individual chart, the Appendix provides some further comments concerning various aspects of AFMDC during its second year of operation.

For a complete analysis of the progress made by the Center from its early inception to the present, the following two references should be reviewed:

"Final Report on the Design of a System for Collecting, Evaluating and Disseminating Machinability Data for Aerospace Materials", Technical Documentary Report Nr. ASD-TDR-63-572, July 1963.

"First Annual Report of the Air Force Machinability Data Center", AFMDC 65-2, February 1966, AD-482 278.

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DESCRIPTION OF AFMDC

AIR FORCE MACHINABILITY DATA CENTER, 3980 Rosslyn Drive, Cincinnati, Ohio 45209.
Operated for the Air Force Materials Laboratory, Manufacturing Technology Division,
under Contract AF 33(615)-5262, by Metcut Research Associates Inc.

SCOPE

The Air Force Machinability Data Center (AFMDC) collects, evaluates, stores, and disseminates material removal information including specific and detailed machining data for the benefit of industry and government. Strong emphasis is given to engineering evaluation for the purpose of developing optimized material removal parameters, such as speeds, feeds, depths of cut, tool material and geometry, cutting fluids and other significant variables. Data are being processed for all types of materials and for all kinds of material removal operations such as turning, milling, drilling, tapping, grinding, electrical discharge machining, electrochemical machining, etc.

COLLECTION

AFMDC has a mechanized system in which punch cards are used to store and retrieve all types of material removal information including all significant numerical data. An IBM 1130 computing system is being used for storing and processing data from a master card and disk file and for computer decoding. The focal concept for acquisition, interrogation, or presentation of information is the specific material (with definite chemical, physical, or mechanical properties) and the specific material removal operation being used. When necessary, card source control codes may be used to retrieve original documents which are in document storage at AFMDC.

INFORMATION SERVICES

AFMDC places strong emphasis on providing specific and detailed answers to technical inquiries in the field of material removal. A User File, consisting of important users in the field of material removal, has been developed to receive information products including machining data pamphlets and tables on materials of current interest, state-of-the-art reports, technical announcements, and other appropriate items. Services are available without charge to the aerospace industry, Department of Defense (including all of the military services and their contractors), and other government agencies, technical institutions, and non-military industries in a position to assist the defense effort.

TO REQUEST MACHINING INFORMATION

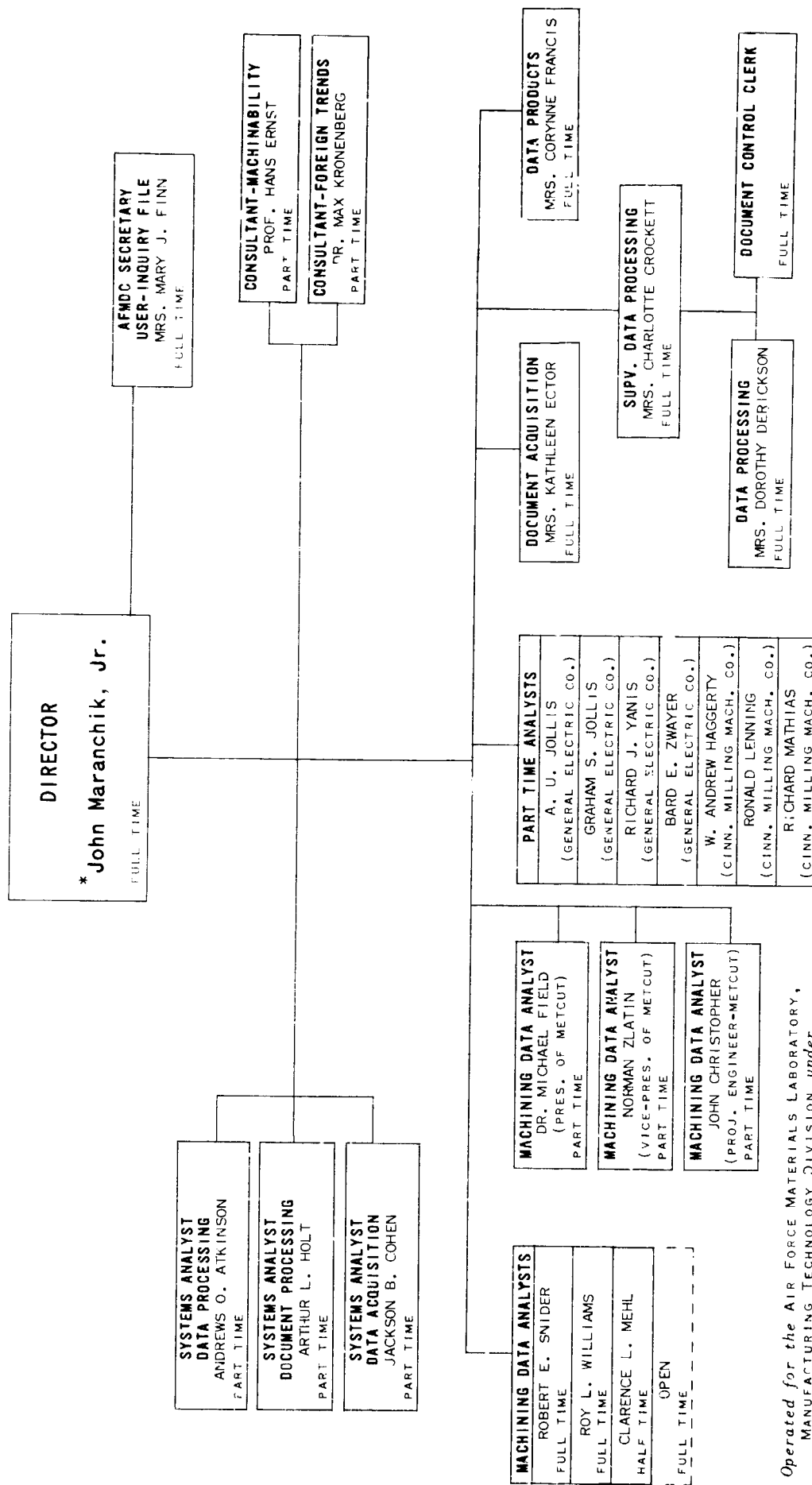
Telephone: 513-271-9510
TWX: 810-461-2840 or
Write: Air Force Machinability Data Center
3980 Rosslyn Drive
Cincinnati, Ohio 45209

TO HELP US ANSWER YOUR INQUIRY, IF POSSIBLE PLEASE:

1. Identify the material being machined (*specification or tradename*); condition, (*as cast, hot rolled, cold drawn, annealed, quenched and tempered, etc.*); microstructure and hardness.
2. Identify the material removal operation in question (*turning, milling, drilling, tapping, surface grinding, electrical discharge machining (EDM), electrochemical machining (ECM), etc.*).
3. Specify reasons for requiring data unless your needs are proprietary. This enables AFMDC to broaden the scope of its technical advice.
4. Specify delivery requirements.
5. Indicate to whom the inquiry reply should be sent.
6. Transmit all details concerning present practices, including feeds, speeds, cutting tool material and geometry, cutting fluids, etc., in the event your inquiry pertains to improvement of an existing machining situation.

NOTE: Association of the names of companies and individuals with specific requests is kept confidential. However, data developed remain the property of AFMDC for dissemination as required for answering similar inquiries and for developing data products.

AFMDC ORGANIZATION CHART*



Operated for the AIR FORCE MATERIALS LABORATORY,
MANUFACTURING TECHNOLOGY DIVISION under
CONTRACT AF 33(615)-5262,
by METCUT RESEARCH ASSOCIATES INC.

--- FUTURE EXPANSION FOR 1967

* EFFECTIVE FEBRUARY 1, 1967, JOHN MARANCHIK, JR. WAS APPOINTED DIRECTOR OF THE DATA CENTER, AND
DR. JOHN F. KAHLES WAS APPOINTED DIRECTOR OF INFORMATION TECHNOLOGY FOR METCUT RESEARCH ASSOCIATES INC.

FIGURE 1

AFMDC OPERATIONAL AREAS

At AFMDC, personnel shown in Figure 1, page 2, work in ten functional areas of operation. These are indicated below along with the numbers used for time coding purposes:

1	Administration	Administration of technical and general activities of AFMDC
2	Engineering Supervision	Technical activities including all mechanized handling of data and processing of inquiries
3	Systems Analysis	Design of the machinability data system, particularly processing
4	Machining Data Analysis	Technical evaluation of machinability data and information including Preliminary Screening
5	Data Processing	Operation of a mechanized system including a computer
6	Data Control	Superimposition and use of controls to guarantee proper operation of data processing system
7	Document Acquisition and Document Storage	Acquisition of all types of data and information for processing. Storage of documents including those which have received Final Technical Evaluation and those in process
8	Data Dissemination	Dissemination including duplication and printing
9	Machining Data Verification - Experimental Machining	Laboratory and shop work necessary for resolving highly significant and controversial data situations
0	Secretarial and Clerical	Development and execution of all procedures relating to typing and filing

AFMDC OPERATIONS CHART

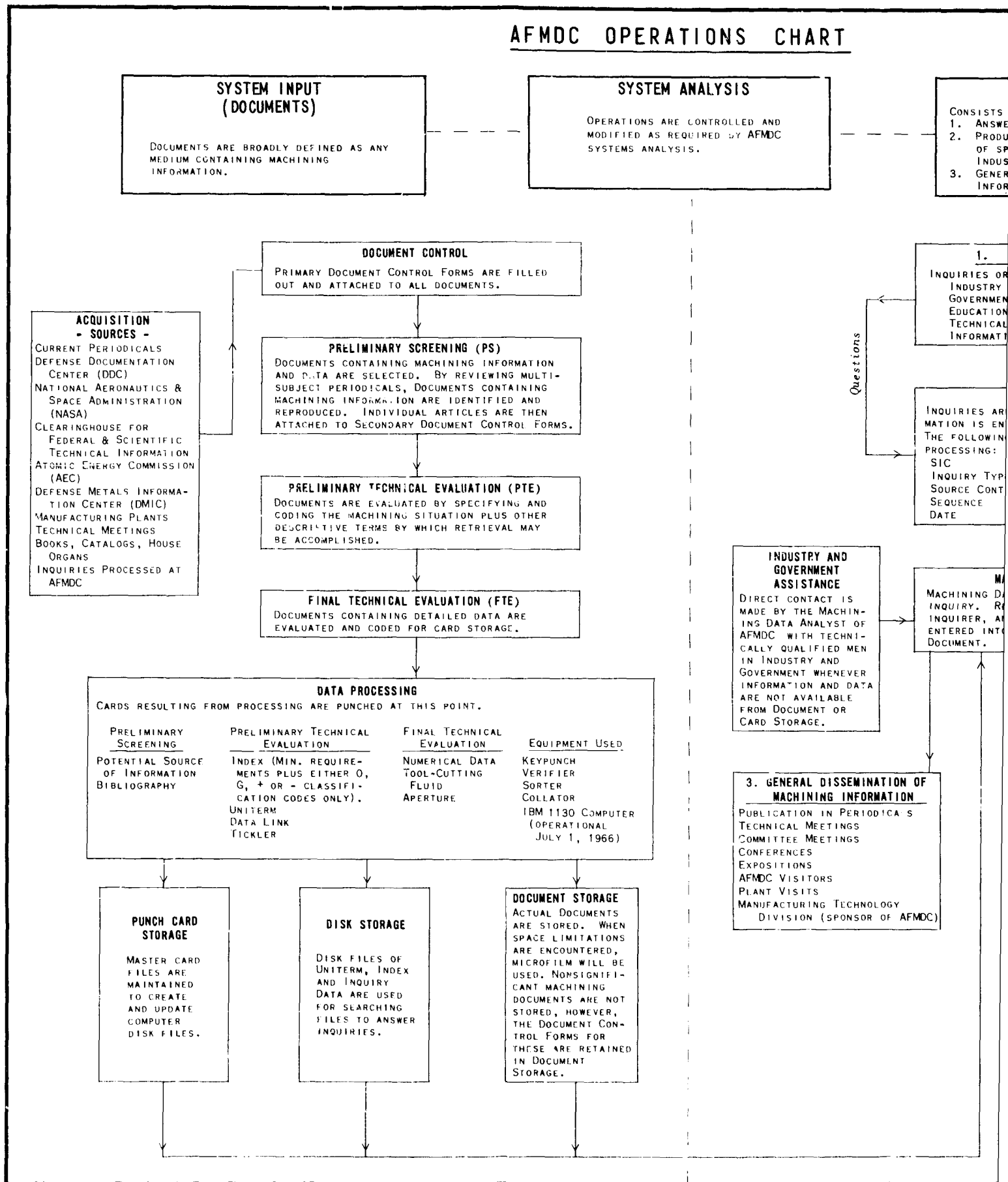


FIGURE 2

AFMDC OPERATIONS CHART

SYSTEM ANALYSIS

OPERATIONS ARE CONTROLLED AND MODIFIED AS REQUIRED BY AFMDC SYSTEMS ANALYSIS.

SYSTEM OUTPUT

- CONSISTS OF:
1. ANSWERING SPECIFIC INQUIRIES.
 2. PRODUCING COMPREHENSIVE DATA PRODUCTS OF SPECIFIC AND TIMELY INTEREST TO INDUSTRY AND GOVERNMENT.
 3. GENERAL DISSEMINATION OF MACHINING INFORMATION.

CONTROL

CONTROL FORMS ARE FILLED IN ALL DOCUMENTS.

SCREENING (PS)

MACHINING INFORMATION IS IDENTIFIED AND QUALIFIED BY REVIEWING MULTIPLE DOCUMENTS CONTAINING MACHINING INFORMATION. QUALIFIED ARTICLES ARE THEN INDEXED ON DOCUMENT CONTROL FORMS.

TECHNICAL EVALUATION (PTE)

TECHNICAL EVALUATION IS PERFORMED BY SPECIFYING AND IDENTIFYING THE SITUATION PLUS OTHER FACTORS WHICH RETRIEVAL MAY BE REQUIRED.

FINAL EVALUATION (FTE)

FINAL EVALUATION DATA ARE ENTERED FOR CARD STORAGE.

INDEXING

INDEXING IS COMPLETED AT THIS POINT.

FINAL TECHNICAL EVALUATION

NUMERICAL DATA
TOOL-CUTTING
FLUID
APERTURE

EQUIPMENT USED

KEYPUNCH
VERIFIER
SORTER
COLLATOR
IBM 1130 Computer
(OPERATIONAL
JULY 1, 1966)

DOCUMENT STORAGE

ACTUAL DOCUMENTS ARE STORED. WHEN SPACE LIMITATIONS ARE ENCOUNTERED, MICROFILM WILL BE USED. NONSIGNIFICANT MACHINING DOCUMENTS ARE NOT STORED, HOWEVER, THE DOCUMENT CONTROL FORMS FOR THESE ARE RETAINED IN DOCUMENT STORAGE.

1. SPECIFIC INQUIRIES

INQUIRIES ORIGINATE FROM:
INDUSTRY
GOVERNMENT
EDUCATIONAL INSTITUTIONS
TECHNICAL SOCIETIES
INFORMATION CENTERS

Questions

INQUIRY CONTROL

INQUIRIES ARE LOGGED IN. ALL NECESSARY INFORMATION IS ENTERED ON AN INQUIRY CONTROL FORM. THE FOLLOWING CODES ARE ASSIGNED FOR CARD PROCESSING:
SIC
INQUIRY TYPE
SOURCE CONTROL (identifies inquirer)
SEQUENCE
DATE
REPLIES TRANSMITTED

Replies

INDUSTRY AND GOVERNMENT ASSISTANCE

DIRECT CONTACT IS MADE BY THE MACHINING DATA ANALYST OF AFMDC WITH TECHNICALLY QUALIFIED MEN IN INDUSTRY AND GOVERNMENT WHENEVER INFORMATION AND DATA ARE NOT AVAILABLE FROM DOCUMENT OR CARD STORAGE.

MACHINING DATA ANALYSIS

MACHINING DATA ANALYSTS ARE ASSIGNED TO EACH INQUIRY. REPLIES ARE TRANSMITTED TO THE INQUIRER, AND THE INQUIRY INFORMATION IS ENTERED INTO THE SYSTEM AS A PRIMARY DOCUMENT.

3. GENERAL DISSEMINATION OF MACHINING INFORMATION

PUBLICATION IN PERIODICALS
TECHNICAL MEETINGS
COMMITTEE MEETINGS
CONFERENCES
EXPOSITIONS
AFMDC VISITORS
PLANT VISITS
MANUFACTURING TECHNOLOGY DIVISION (SPONSOR OF AFMDC)

2. DATA PRODUCTS

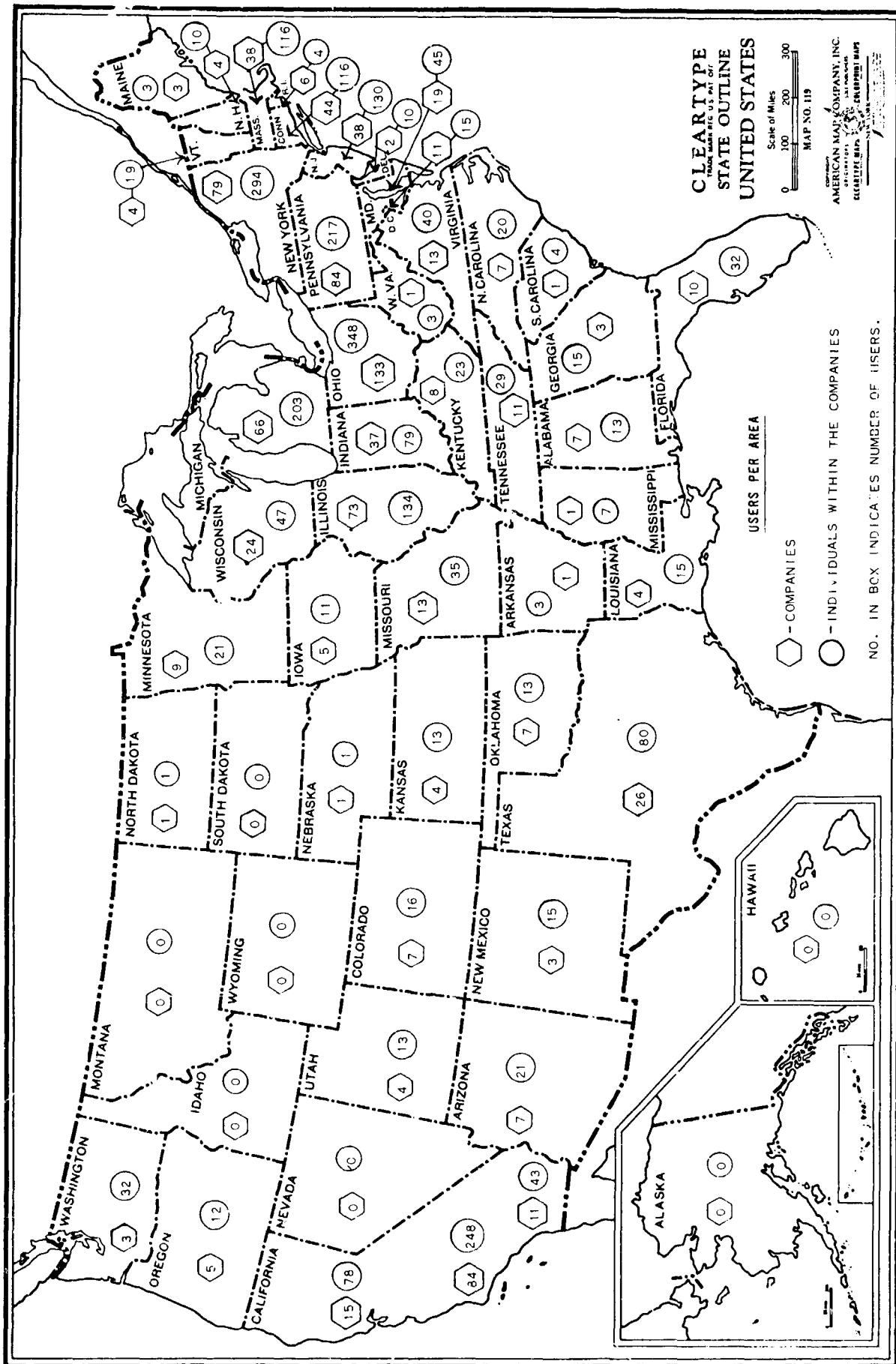
FIRST ANNUAL REPORT OF THE AIR FORCE MACHINABILITY DATA CENTER, AFMDC 65-2
MACHINING DATA FOR NUMERICAL CONTROL (7 INDIVIDUAL REPORTS NOS. AFMDC 66-1.1 THRU AFMDC 66-1.7 COVERING TURNING, FACE MILLING, DRILLING, PERIPHERAL END MILLING, END MILL SLOTTING, TAPPING & REAMING RESPECTIVELY).
MACHINING DATA FOR NUMERICAL CONTROL, AFMDC 66-1 (COMPOSITE OF ABOVE MENTIONED 7 REPORTS).
GRINDING RATIOS FOR AEROSPACE ALLOYS, AFMDC 66-2
MACHINING DATA FOR BERYLLIUM METAL, AFMDC 66-3

USER FILE

THE USER FILE CONSISTS OF:
MAJOR MISSILE AND AEROSPACE MANUFACTURERS AND THEIR SUBCONTRACTORS
DEPARTMENT OF DEFENSE (INCLUDING ALL OF THE MILITARY SERVICES AND THEIR CONTRACTORS), AND OTHER GOVERNMENT AGENCIES
NONMILITARY INDUSTRIES IN A POSITION TO ASSIST THE DEFENSE EFFORT
AEROSPACE INDUSTRIES ASSOCIATION (AIA) MANUFACTURING COMMITTEE
COLLEGES AND UNIVERSITIES
INFORMATION CENTERS
TECHNICAL SOCIETIES
TRADE PUBLICATIONS
AFMDC INQUIRERS
MATERIALS ADVISORY BOARD (MAB) COMMITTEES

TOTAL - 3574 (1/31/67)

AFMDC USER FILE MAP



DISTRIBUTION OF AFMDC USER FILE

The basic User File was developed as indicated in Appendix, Page A-4. Names are added to the User File as a result of 1) inquirers, 2) visitors, 3) additional names submitted by current Users, 4) requests resulting from dissemination of data products, and 5) technical articles published in periodicals and announcements pertaining to the Center.

GENERAL CONCENTRATION OF USERS BY NUMBER

<u>STATES *</u>	<u>COMPANIES</u>	<u>USERS **</u>	<u>AVERAGE USERS/COMPANY</u>
6	0	0	0
28	1-10	1-25	2.5
6	11-25	26-50	2.1
5	26-50	51-125	2.3
4	51-100	126-300	2.8
2	OVER 100	OVER 300	3.2

AREA CONCENTRATION OF COMPANIES

West Coast (3 states) -	118 companies
North Midwest (5 states) -	333 companies
Northeast (5 states) -	283 companies

These figures indicate that 75% of User companies lie in 25% of the United States.

The total User File can be broken down as follows:

Individuals	2,649
Companies	925
College Users (individuals)	747
Societies, Centers, etc. (individuals)	158

*Includes Washington, D.C.

**Includes Universities.

WELCOME TO AFMDC VISITOR

* * WELCOME TO THE AIR FORCE MACHINABILITY DATA CENTER * *

JOHN SMITH MEG ENGR GEMINI MEC

YOU ARE NOW REGISTERED AND HAVE BECOME A PART OF OUR SYSTEM, AS A VISITOR, POSSIBLE INQUIRER, AND POTENTIAL SOURCE OF INFORMATION. THE AIR FORCE MACHINABILITY DATA CENTER, UNDER CONTRACT NUMBER AF-33(615)-5262, COLLECTS, EVALUATES, STORES, RETRIEVES, AND DISSEMINATES MATERIAL REMOVAL DATA AND OTHER INFORMATION FOR THE BENEFIT OF INDUSTRY AND GOVERNMENT AS REQUIRED TO ANSWER INQUIRIES WHICH MAY ORIGINATE FROM ANY OF THE 50 UNITED STATES FOR THE AEROSPACE INDUSTRY, DEPARTMENT OF DEFENSE, TECHNICAL INDUSTRIES AND MANY OTHERS.

YOUR REGISTRATION IS BEING PREPARED ON AN I.B.M. 1130 COMPUTING SYSTEM WHICH IS THE DATA STORAGE AND RETRIEVAL MECHANISM FOR THE AIR FORCE MACHINABILITY DATA CENTER.

* * YOUR HOST HAS BEEN * *

JOHN MARANCHIK DIRECTOR A F M D C

IT MAY BE OF INTEREST FOR YOU TO KNOW THAT IN EXCESS OF \$34,000,000,000 ARE SPENT ANNUALLY IN LABOR AND OVERHEAD ALONE FOR REMOVING METAL IN METAL WORKING INDUSTRIES IN THE UNITED STATES. AFMDC BELIEVES THAT WE NEED GOOD DATA TO BE EFFECTIVE IN THIS TYPE OF ECONOMIC CLIMATE.

--- A MAN'S JUDGMENT IS NO BETTER THAN HIS DATA ---

COMPUTER INPUT AND OUTPUT FLOW CHART

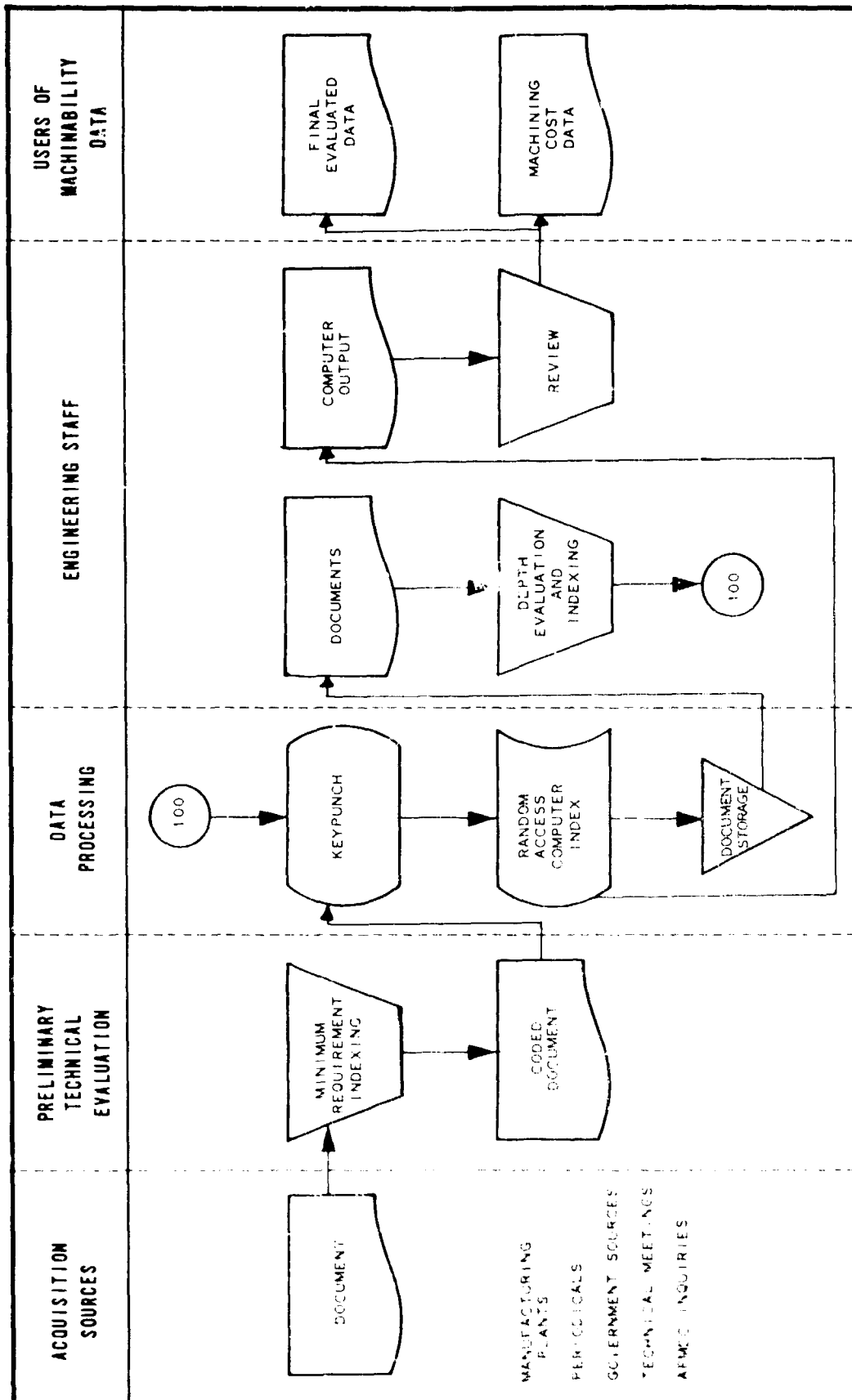


FIGURE 4

DATA CODE FORMS FOR FINAL TECHNICAL EVALUATION

OPERATION (check one)			
DRILL	TURN	BORE	
REAM	TURN	BORE	
DRILL	TURN	BORE	
DRILL	TURN	BORE	

DATA CODE FORM #1-1

Date 12-15-66

Code by R.L.W.

CONTROL CODES			
DATA SOURCE			
CODE	YEAR	INDEX	
0000000000000000	00	00	

HARD- NESS	MATERIAL CND	HT TAT	MATERIAL GROUP	MATERIAL DESCRIPTION	PART		MACHINE TOOL										C A R D	FROM	TO
					CONFIG.	TOOL MATERIAL	TYPE	SIZE	SFR.	NOO	NP	ACE	C	W					
029	01	0301	INCO718	22234	Y	3-4	1631	1631	0000	0000	0000	0000	0000	0000	0000	0000	0000		
						3-4													
						3-4													
						3-4													
						3-4													
						3-4													
						3-4													
						3-4													

CUTTING SPEED FT. MIN.	FEED IN. REV.	DEPTH OF CUT INCHES	TOOL LIFE MINUTES	WEARLAND INCHES	SEQ. NO.	S D
00125	00000	00000	00000	00000	00000	00000
00125	00000	00000	00000	00000	00000	00000
00125	00000	00000	00000	00000	00000	00000
00070	00000	00000	00000	00000	00000	00000
00070	00000	00000	00000	00000	00000	00000

SURFACE FINISH IN.	UNIT NP NP/IN. IN.	SEQ. NO.	S D
00000	00000	00000	00000
00000	00000	00000	00000
00000	00000	00000	00000
00000	00000	00000	00000
00000	00000	00000	00000

OPERATION CODE	
001	SINGLE POINT TURNING
002	FACING CUT TURNING
003	THREADING
004	THREADING
005	MULTI-EDGE CHAMFER
006	TRACING BY CONTOUR
007	CHAMFER
008	BOX TOOL TURNING
009	CENTERLESS
010	MULTI-POINT TURNING

SIDE 1

TOOL - CUTTING FLUID #1														
TOOL STYLE	"BACK RAKE"	"SIDE RAKE"	END REL	SIDE REL	"FACE"	"SCRA"	ROSE RADIUS	CHIP-BREAKER TYPE	CHIP-BREAKER WIDTH-IN.	CHIP-BREAKER DEPTH-IN.	TOOL MATERIAL	CUTTING FLUID	CONCENTRATION	SEQ. NO.
11	161	00	00	00	00	00	00	00	00	00	00	00	00	00

COLUMN 1 (TYPE)

- 1 - SOLID
- 2 - DRILLED INSERT
- 3 - THREADED INSERT

COLUMN 2 (SHAPE OF INSERT)

- 0 - NONE
- 1 - SQUARE
- 2 - TRIANGLE
- 3 - ROUND
- 4 - PENTAGON
- 5 - DIAMOND
- 6 - UNIFORM

COLUMN 3 (LOCKING METHOD)

- 1 - CLAMPING
- 2 - PIN LOCK

COLUMNS 4 & 5 (SHAPE SIZE OF HELDER OR TOOL BIT)

- IF TOOL IS SQUARE CODE BY 1/16" x 1/16"
- IF TOOL IS RECTANGLE CODE BY 1/16" x 1/16" OR 1/16" x 1/16" OR 1/16" x 1/16"
- IF TOOL IS ROUND CODE BY 1/16" x 1/16" OR 1/16" x 1/16"
- SQUARE - 16 1/16" x 1/16" SQUARE
- RECTANGLE - 64 1/16" x 1/16" x 1/16" x 1/16"
- ROUND - 8 1/16" DIAMETER

COLUMN 6

- 1 - RIGHT HAND CUTTING
- 2 - LEFT HAND CUTTING
- 3 - END CUTTING
- 4 - BORING
- 5 - FOLDER TURNING
- 6 - CUTOFF
- 7 - PLANING
- 8 - SHAPING

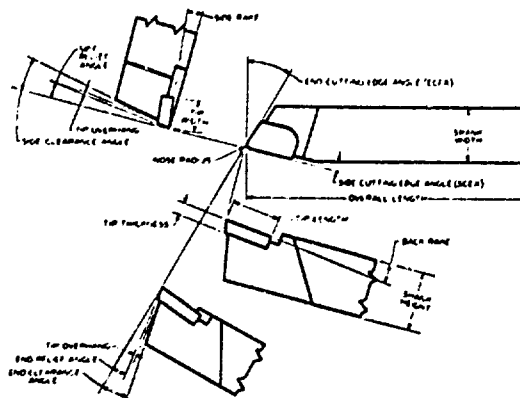
* Insert appropriate plus or minus sign.

COLUMN 7 (CH. PREPARER)

- 1 - MECHANICAL
- 2 - GRIND
- 3 - HAND
- 4 - UNLOD

COLUMN 8 (CHIPBREAKER TYPE)

- 1 - ANGULAR
- 2 - PARALLEL
- 3 - GROOVE
- 4 - 45 ANGULAR
- 5 - REVERSE ANGULAR



SIDE 2

FLOW CHART FOR FORTRAN PROGRAM TO STORE, ADD C

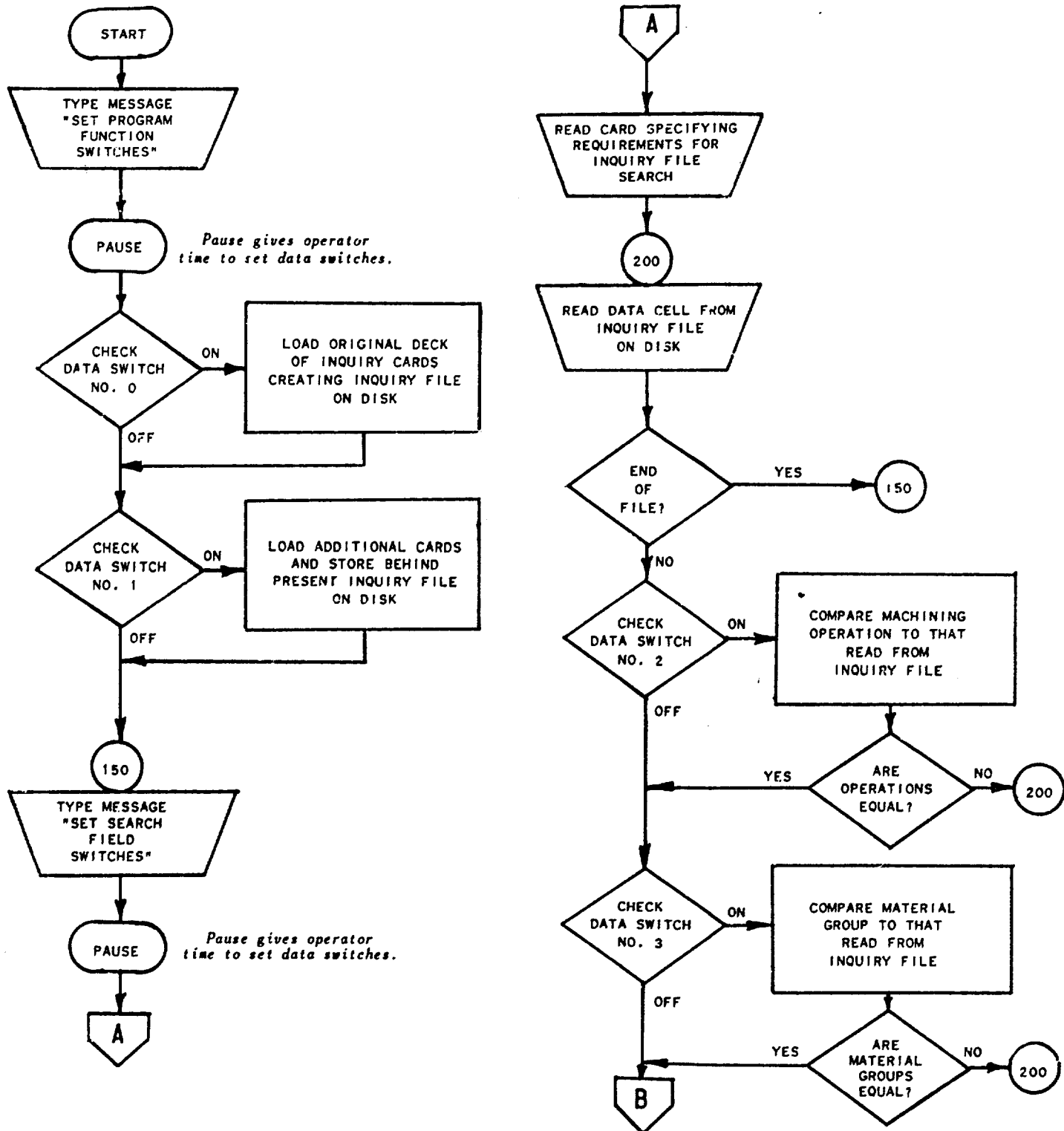
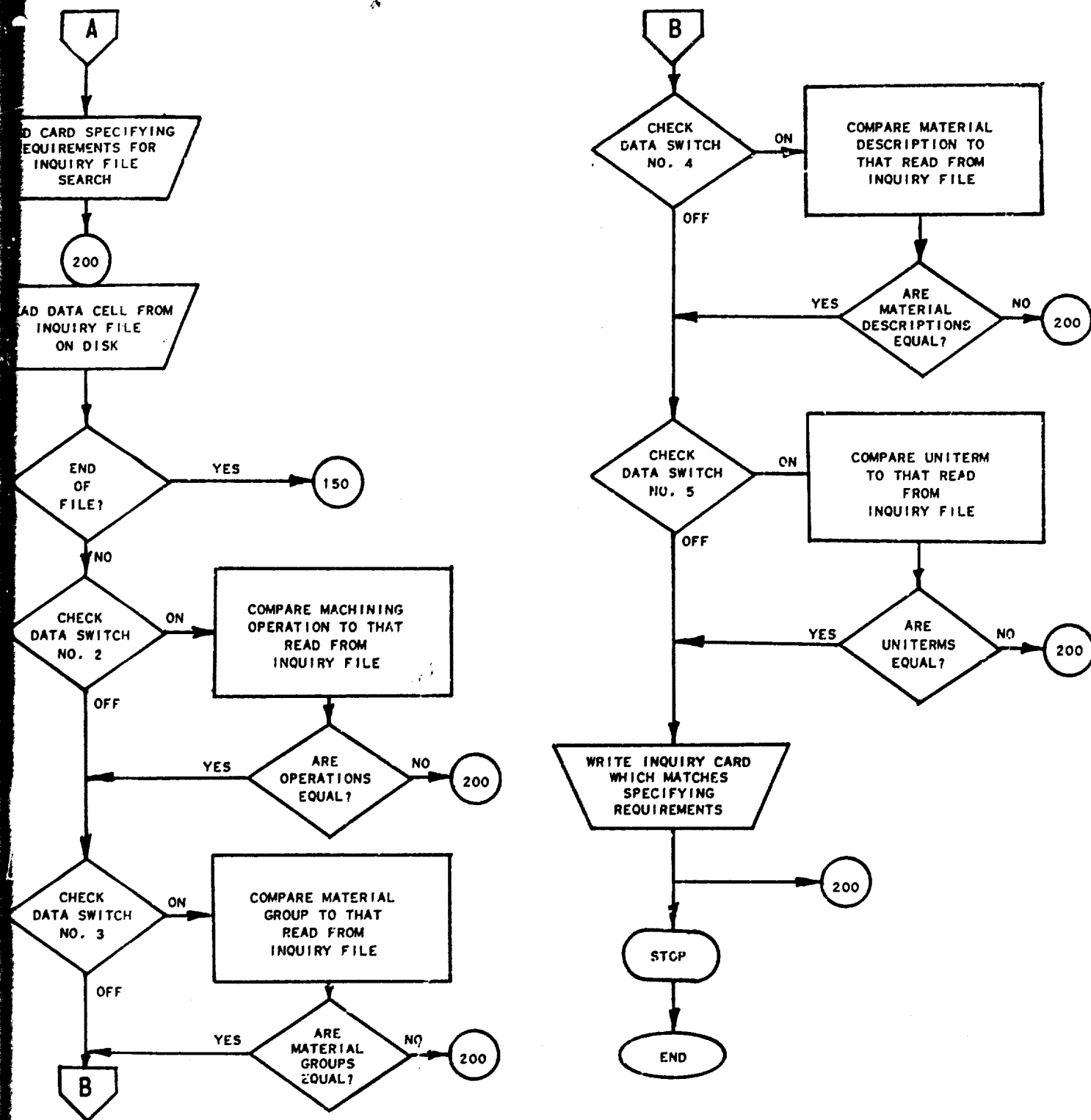


FIGURE 6

RT FOR FORTRAN PROGRAM TO STORE, ADD OR SEARCH INQUIRY FILE



INQUIRY FILE SEARCH

SEE APPENDIX, PAGE A-9

CONTROL ON DATA SWITCH NO. 5 - UNITERM. CUT FLUID

OPER	MG	MAT DESCRP	UNITERMS	SIC	CO	SEQ	DATE
0	0		0 CUT FLUID				
170	301	INCOX750	1 CUT FLUID	3541	41 11	63	2015
0	0		14 CARB TOOLSCUT FLUID	3610	42 11	97	3035
0	301	WASPALOY	2 CUT FLUID TOOL GEOM	3722	79 11	112	3045
0	0		14 CUT FLUID STRESS -CORROSION	2911	82 11	119	3125
1	301	INCOX750	13 CUT FLUID	3722	35 11	138	3185
85	301	INCOX750	13 CUT FLUID	3722	35 1	138	3185
55	301	INCOX750	13 CUT FLUID	3722	35 1	138	3185
1	301	INCO722	13 CUT FLUID	3722	35 1	138	3185

SET SEARCH FIELD SWITCHES

CONTROL ON DATA SWITCHES NOS. 3, 4 & 5 - MATL GRP, 301: MATL DESCRIP, INCO X750; UNITERM, CUT FLUID

OPER	MG	MAT DESCRP	UNITERMS	SIC	CO	SEQ	DATE
0	301	INCOX750	0 CUT FLUID				
170	301	INCOX750	1 CUT FLUID	3541	41 11	63	2015
1	301	INCOX750	13 CUT FLUID	3722	35 11	138	3185
85	301	INCOX750	13 CUT FLUID	3722	35 1	138	3185
55	301	INCOX750	13 CUT FLUID	3722	35 1	138	3185

SET SEARCH FIELD SWITCHES

CONTROL ON DATA SWITCHES NOS. 2, 3, 4 & 5 - OPERATION, 085 (DRILLING); MATL GRP, 301: MATL DESCRIP, INCO X750; UNITERM, CUT FLUID

OPER	MG	MAT DESCRP	UNITERMS	SIC	CO	SEQ	DATE
85	301	INCOX750	0 CUT FLUID				
85	301	INCOX750	13 CUT FLUID	3722	35 1	138	3185

FIGURE 7

FIGURE 8

OUTPUT OF PRELIMINARY TECHNICAL EVALUATED DATA AND UNITERM

PRELIMINARY INDEX FILE SEARCH

OPER	HDN	MC	HT	MTG	MAT DESCRIP	TM	SOURCE CONTROL CODE
85	885	01	60	301	INCO702	HS	610000 &600001401011
85	C35	01	61	301	INCO901	HS	610000 &600001401011
85	C33	01	61	301	INCO702	HS	610000 &600001401011
85	C35	03	62	301	INCOX750	HS	90300004640001213141
85	C30	03	60	301	INCOX750	C	90300004640001307071
85	C40	01	52	301	WASPALOY	HS	90300004640001304041
85	C40	01	62	301	WASPALOY	C	90300004640001305051
85	C35	61	301	INCO700	HS	999004 &640001401021	
85	C33	60	301	INCO700	C	999013 &650001401021	
85	C39	62	301	RENE41	C	999013 &650001401021	
85	C39	62	301	UDIMET500	C	999013 &650001401021	
85	C35	10	301	RENE41	HS	999041 &630001401011	

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UNITERM FILE SEARCH

SURF	-INTEGRITY	
SURF	-INTEGRITY	114000 G650001 01 4
SURF	-INTEGRITY	203004 &650003 01 4
SURF	-INTEGRITY	212007 G620001 01 4
SURF	-INTEGRITY	212034 &640001 02 4
INSPECTIONSURF	-INTEGRITY SURF FIN	214011 G650001 01 4
MCHNBITY	-PROCESS -EFFECT SURF	-INTEGRITY SURF FIN 219013 &660002 01 4
SURF	-INTEGRITY FATIGUE -LIFE	219021 G660002 01 4

OUTPUT OF FINAL TECHNICAL EVALUATED DATA

MACHINING	MATERIAL	HEAT TREAT	MATERIAL	A F M D C	DATA	INDEX	
OPERATION	GROUP DESCRIPTION	CONDITION	HARDNESS	SOURCE	STATUS	CLASS	
TURN, SINGLE PNT	301 INCO718	SOLUTIONED	ROCK C29				INQUIRY
TURN, SINGLE PNT	301 INCO718	SOLUTIONED	ROCK C29	950002 660019	FB		AFMDC

TOOL * LACK * SIDE * END * SIDE * ECEA * SCEA * * NOSE * CHIP BREAKER *
TOOL GEOMETRY * STYLE * RAKE * RAKE * RELF * RELF * * * RADIUS * TYPE * WIDTH * DEPTH *
***** (SEE CHART) * DEG * DEG * DEG * DEG * DEG * DEG * * INCHES * * INCH * INCH *
11 161 00 0 05 05 05 15 15 0.032 ***** ***** AFMDC

TOOL * ATL-FLUID *	TOOL *	CUTTING FLUID	CUTTING FLUID	CUTTING FLUID
MATERIAL *	MATERIAL *	TRADE NAME	DESCRIPTION	CONCENTRATION
C2 K68 NOT REPORTED	WATER SOLUBLE OIL - LIGHT DUTY			1 TO 020 AFMDC

CUT * FEED * DEPTH * TOOL * WEAR * SURE * UNIT *						
NUMERICAL DATA * SPEED * IN/REV * INCH * MIN * LIFE * MIN * FIN * RMS * HP/CUIN *						
125. 0.009 0.060 10. 0.015 ***** 2.000 ***** *****						AFMDC
110. 0.009 0.060 15. 0.015 ***** 2.000 ***** *****						AFMDC
98. 0.009 0.060 30. 0.015 ***** 2.000 ***** *****						AFMDC
90. 0.009 0.060 45. 0.015 110. 2.000 ***** *****						AFMDC

FIGURE 10

COST AND PRODUCTION RATE FOR TURNING

SPAZED CARBIDE TOOLS

DATA SET NO	WORK MATERIAL	HARDNESS	TOOL	CUT SPD F/M	FEED IN/REV	LIFE MIN	*FEED*RAPD*LOAD*	SET*TOOL*TOOL*RE*	*ILP*GRIND*	**TOTAL**PROD
							*COST*TRAV*UNLD*	UP *CHNG*DEPR*SHPN*BRAZ*	COST*WHEEL*	**COST **RATE
							*\$ *\$ *\$ *\$ *\$ *	*\$ *\$ *\$ *\$ *\$ *	*\$ *\$ *	**\$/PC **PC/HR
1	AISI 4340	221 C-7		545	0.0100	15	0.30 0.02 0.20 0.07 0.10 0.03 0.20 0.03	0.00 0.00	0.00	1.00 13.3
2	AISI 4340	221 C-7		440	0.0100	30	0.37 0.02 0.20 0.07 0.06 0.01 0.12 0.02	0.00 0.00	0.00	0.92 12.6
3	AISI 4340	221 C-7		380	0.0100	45	0.43 0.02 0.20 0.07 0.04 0.01 0.09 0.01	0.00 0.00	0.00	0.93 11.9
4	AISI 4340	221 C-7		340	0.0100	60	0.48 0.02 0.20 0.07 0.04 0.01 0.08 0.01	0.00 0.00	0.00	0.95 11.2

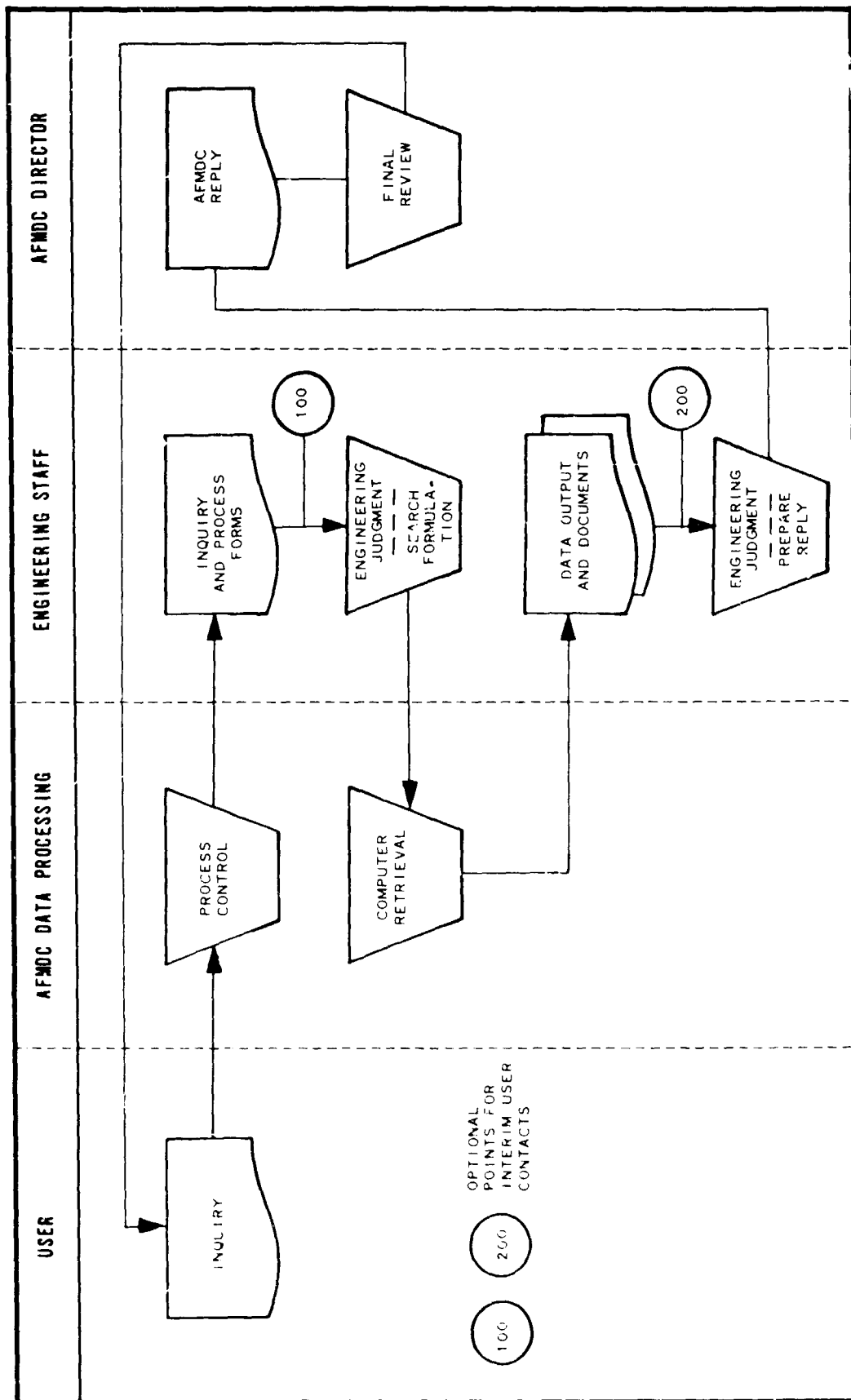
THROWAWAY CARBIDE TOOLS

DATA SET NO	WORK MATERIAL	HARDNESS	TOOL	CUT SPD F/M	FEED IN/REV	LIFE MIN	*FEED*RAPD*LOAD*	SET*TOOL*TOOL*RE*	*ILP*GRIND*	**TOTAL**PROD
							*COST*TRAV*UNLD*	UP *CHNG*DEPR*SHPN*BRAZ*	COST*WHEEL*	**COST **RATE
							*\$ *\$ *\$ *\$ *\$ *	*\$ *\$ *\$ *\$ *\$ *	*\$ *\$ *	**\$/PC **PC/HR
1	AISI 4340	221 C-7		545	0.0100	15	0.30 0.02 0.20 0.07 0.00 0.00	0.02	0.00	0.64 15.4
2	AISI 4340	221 C-7		440	0.0100	30	0.37 0.02 0.20 0.07 0.00 0.00	0.01	0.00	0.70 13.7
3	AISI 4340	221 C-7		380	0.0100	45	0.43 0.02 0.20 0.07 0.00 0.00	0.01	0.00	0.76 12.6
4	AISI 4340	221 C-7		340	0.0100	60	0.48 0.02 0.20 0.07 0.00 0.00	0.00	0.00	0.81 11.8

SOLID HIGH SPEED TOOLS

DATA SET NO	WORK MATERIAL	HARDNESS	TOOL	CUT SPD F/M	FEED IN/REV	LIFE MIN	*FEED*RAPD*LOAD*	SET*TOOL*TOOL*RE*	*ILP*GRIND*	**TOTAL**PROD
							*COST*TRAV*UNLD*	UP *CHNG*DEPR*SHPN*	*WHEEL*	**COST **RATE
							*\$ *\$ *\$ *\$ *\$ *	*\$ *\$ *\$ *\$ *\$ *	*\$ *\$ *	**\$/PC **PC/HR
16	AISI 4340	221 T-1		100	0.0090	15	1.79 0.02 0.20 0.07 0.59 0.04 1.79		0.01	4.56 3.3
17	AISI 4340	221 T-1		88	0.0090	30	2.08 0.02 0.20 0.07 0.34 0.02 1.04		0.00	3.82 3.3
18	AISI 4340	221 T-1		78	0.0090	45	2.34 0.02 0.20 0.07 0.26 0.01 0.78		0.00	3.73 3.1
19	AISI 4340	221 T-1		70	0.0090	60	2.61 0.02 0.20 0.07 0.21 0.01 0.65		0.00	3.82 2.8

INQUIRY PROCESSING FLOW CHART



ANALYSIS OF SPECIFIC INQUIRIES BY MATERIAL GROUP

OCTOBER 1, 1964 - JANUARY 31, 1967

MATERIAL GROUP	NO. OF REQUESTS	NO. OF MACHINING OPERATIONS
PLAIN CARBON & LOW ALLOY STEELS	88	59
ULTRA HIGH STRENGTH & TOOL STEELS	17	39
CAST IRONS	30	41
STAINLESS STEELS	66	64
NICKEL ALLOYS	22	15
MARAGING STEELS	21	41
HIGH TEMPERATURE ALLOYS	214	79
TITANIUM ALLOYS	160	46
REFRACTORY ALLOYS	117	106
ALUMINUM, MAGNESIUM, ZINC, LEAD & COPPER ALLOYS	66	50
PRECIOUS & RARE METALS	7	8
NONMETALLICS INCLUDING CERAMICS, PLASTICS & GRAPHITE	38	12
TOTALS	846	590

ANALYSIS OF COMPREHENSIVE AND UNITERM TYPE INQUIRIES

TYPE OF INQUIRY	NO. OF INQUIRIES
ONE OPERATION ON A VARIETY OF MATERIAL GROUPS	168
SEVERAL OPERATIONS ON ONE MATERIAL GROUP	276
SEVERAL OPERATIONS ON A VARIETY OF MATERIAL GROUPS	56
GENERAL MACHINING CONCEPTS (UNITERMS)	502
TOTAL	1,002

ANALYSIS OF INQUIRIES BY TYPE OF MACHINING OPERATION

OCTOBER 1, 1964 - JANUARY 31, 1967

OPERATION	NO. OF REQUESTS
CONVENTIONAL CHIP REMOVAL	
TURNING	325
BORING	74
MILLING (GENERAL)	45
FACE MILLING	136
END MILL SLOTTING	102
PERIPHERAL END MILLING	90
SLAB MILLING	8
THREAD MILLING	9
ALL OTHER TYPES OF MILLING	20
DRILLING	259
GUN DRILLING	8
REAMING	107
TAPPING	120
GEAR CUTTING	4
BROACHING	47
ROUTING	4
BANDSAWING	13
HACKSAWING	11
CONVENTIONAL GRINDING	
GENERAL GRINDING	69
SURFACE GRINDING	89
CYLINDRICAL GRINDING	35
INTERNAL GRINDING	7
CENTERLESS GRINDING	6
GEAR GRINDING	3
THREAD GRINDING	5
TOOL GRINDING	8
ABRASIVE MACHINING	2
ABRASIVE BELT GRINDING	3
ABRASIVE CUTOFF	7
HONING	6
ALTERNATE MACHINING METHODS	
ALTERNATE MACHINING METHODS (GENERAL)	6
ELECTRICAL DISCHARGE MACHINING	39
ELECTROCHEMICAL MACHINING	31
ELECTROCHEMICAL GRINDING	19
CHEMICAL MACHINING	7
ULTRASONIC MACHINING	6
ELECTRON BEAM MACHINING	6
PLASMA JET MACHINING	2
LASER MACHINING	3
ABRASIVE JET MACHINING	1
MISCELLANEOUS	
DEBURRING	9
BURNISHING	5
CONTROLLED ENERGY MACHINING	1
SUB-ZERO MACHINING	5
HOT MACHINING	1
TOTAL	1,763

SUMMARY OF SPECIFIC INQUIRIES BY TYPE OF INQUIRY

February 1, 1966 - January 31, 1967

	NO. OF INQUIRIES
1. RECOMMENDATIONS FOR A SPECIFIC MACHINING SITUATION. <i>Typical Example:</i> Requested recommendations for turning Waspaloy in the solution treated and aged condition.	116
2. STARTING RECOMMENDATIONS FOR AN EXTENSIVE GROUP OF MACHINING SITUATIONS. <i>Typical Example:</i> Requested machinability data on AM-350, S-816, HS-25, HS-31, Inconel X-750, Unitemp, Udimet M-252 and Hastelloy R-235.	264
3. INFORMATION PERTAINING TO NEW MACHINING PROCESSES, EQUIPMENT AND TOOLS. <i>Typical Example:</i> Requested information on the manufacturer of equipment called "Liquid Lathe."	27
4. COORDINATION AND POTENTIAL USE OF AFMDC. <i>Typical Example:</i> Requested detailed information on services available from AFMDC.	29
5. VISITS TO THE CENTER. <i>Typical Example:</i> Visited to coordinate with AFMDC to determine services available and to review System details.	78
6. * REQUESTS FOR SPECIFIC DOCUMENTS, REPORTS, BOOKS, PAPERS, ETC. <i>Typical Example:</i> Requested a list of reports available for machining of titanium. Also wanted cost of each report.	71
7. GENERAL INFORMATION SUCH AS SAFETY PRACTICES, NAMES OF FIRMS HAVING CERTAIN MACHINING CAPABILITIES, TOOL MATERIAL PROPERTIES, ETC. <i>Typical Example:</i> Requested the names of people to contact in the fields of metal removal such as EDM, ECM, ECG, EDG, USM, CHM, EBM, LBM, Abrasive Machining and Hot Machining.	30
8. REQUESTS FOR BIBLIOGRAPHIES AND ABSTRACTS. <i>Typical Example:</i> Request for bibliographies with abstracts covering use of ceramic tools and abrasives in machining various materials.	4
9. STATE-OF-THE-ART INFORMATION AND REPORTS. <i>Typical Example:</i> Suggestions for important manufacturing programs for the next five years in the field of material removal. Supply problem, approach and approximate funds.	8
10. SPECIAL INQUIRIES AND REPORTS FOR U.S. AIR FORCE, MANUFACTURING TECHNOLOGY DIVISION. <i>Typical Example:</i> Requested a report on the progress during the last five years in machining of titanium and hard to machine materials - state of the art.	4
11. EVALUATION, TRANSLATION AND REVIEW OF REPORTS, BOOKS, PAPERS. <i>Typical Example:</i> Requested an evaluation of a report published in Electro-Technology, October 1964, concerning adaptive control possibilities.	12
12. REQUEST FOR INFORMATION ON BERYLLIUM. <i>Typical Example:</i> Request for information on machinability data for beryllium using ECM, EDM, and other methods.	15
13. COMPARISON OF ONE PROCESS OR MATERIAL WITH ANOTHER. <i>Typical Example:</i> Requested a comparison of the machining of Inconel W with Inconel X in both solution treated and solution treated and aged conditions, primarily in turning but also drilling and milling if possible.	13
14. INFORMATION PERTAINING TO CUTTING FLUIDS. <i>Typical Example:</i> Requested cutting fluid recommendations for titanium and a wide variety of high temperature alloys and stainless steels.	22
15. INFORMATION ON MACHINABILITY RESEARCH. <i>Typical Example:</i> Requested machining information on the effect of work diameter on tool life, mathematical correlations of the various machining processes and the means of predicting the surface quality in milling.	37
16. INFORMATION PERTAINING TO ESTIMATING COST, SETTING TIME STANDARDS, AND PRODUCTION RATES IN MACHINING. <i>Typical Example:</i> Requested information including formulas that could be used to predict production rates and costs.	6
TOTAL	736

*This total does not include requests for published data products such as AFMDC reports.

AIR FORCE MACHINABILITY DATA CENTER

SUMMARY OF SPECIFIC INQUIRIES BY SIC* NUMBER

February 1, 1966 - January 31, 1967

SIC MAJOR GROUP NO.	SIC INDUSTRY NO.		NUMBER OF INQUIRIES		
			BY SIC INDUSTRY NO.	BY SIC MAJOR GROUP NO.	% OF TOTAL
91		FEDERAL GOVERNMENT		36	4.9
	9100	USAF - WRIGHT FIELD	11		
	9100	USAF - ANDREWS AIR FORCE BASE	1		
	9100	USAF - TINKER AIR FORCE BASE	4		
	9100	U.S. ARMY	10		
	9100	U.S. NAVY	5		
	9100	NATIONAL AERONAUTICS & SPACE ADMINISTRATION	2		
	9100	SMALL BUSINESS ADMINISTRATION	1		
	9137	PHILADELPHIA NAVAL SHIPYARD	1		
	9190	BOSA DEPARTMENT OF COMMERCE	1		
19	1921	ORDNANCE AND ACCESSORIES ARTILLERY AMMUNITION	1	1	0.1
28	2621	PAPER AND ALLIED PRODUCTS PAPER MILLS, EXCEPT BUILDING PAPER MILLS	1	1	0.1
27	2721	PRINTING, PUBLISHING, AND ALLIED INDUSTRIES PERIODICALS: PUBLISHING, PUBLISHING AND PRINTING	6	6	0.8
28		CHEMICALS AND ALLIED PRODUCTS		12	1.6
	2811	INDUSTRIAL INORGANIC AND ORGANIC CHEMICALS	1		
	2813	INDUSTRIAL GASES	1		
	2818	INDUSTRIAL ORGANIC CHEMICALS	2		
	2819	INDUSTRIAL INORGANIC CHEMICALS	1		
	2821	PLASTICS MATERIALS, SYNTHETIC RESINS, & NONVULCANIZABLE ELASTOMERS	2		
	2833	MEDICINAL CHEMICALS AND BOTANICAL PRODUCTS	5		
29	2911 2992	PETROLEUM REFINING AND RELATED INDUSTRIES PETROLEUM REFINING LUBRICATING OILS AND GREASES	5 1	6	0.8
31	3121	LEATHER AND LEATHER PRODUCTS INDUSTRIAL LEATHER BELTING AND PACKING	1	1	0.1
32	3229 3264 3291 3297	STONE, CLAY, AND GLASS PRODUCTS PRESSED AND BLOWN GLASS AND GLASSWARE PORCELAIN ELECTRICAL SUPPLIES ABRASIVE PRODUCTS NONCLAY REFRACTORIES	2 1 7 1	11	1.5
33	3312 3321 3323 3332 3334 3339 3341 3369 3391	PRIMARY METAL INDUSTRIES BLAST FURNACES (INCLUDING COKE OVENS), STEEL WORKS, & ROLLING MILLS GRAY IRON FOUNDRIES STEEL FOUNDRIES PRIMARY SMELTING AND REFINING OF LEAD PRIMARY PRODUCTION OF ALUMINUM PRIMARY SMELTING & REFINING OF NONFERROUS METALS SECONDARY SMELTING, REFINING & ALLOYING OF NONFERROUS METALS AND ALLOYS NONFERROUS CASTINGS IRON AND STEEL FORGINGS	4 2 10 7 1 17 4 7 7	59	8.1

*Standard Industrial Classification Manual (SIC), Executive Office of the President, Bureau of the Budget, 1957, and the Supplement to 1957 Edition Standard Industrial Classification Manual, 1963.

SIC MAJOR GROUP NO.	SIC INDUSTRY NO.		NUMBER OF INQUIRIES		
			BY SIC INDUSTRY NO.	BY SIC MAJOR GROUP NO.	% OF TOTAL
34		FABRICATED METAL PRODUCTS, EXCEPT ORDNANCE, MACHINERY, AND TRANSPORTATION EQUIPMENT		33	4.5
	3423	HAND AND EDGE TOOLS, EXCEPT MACHINE TOOLS & HAND SAWS	1		
	3433	HEATING EQUIPMENT, EXCEPT ELECTRICAL	1		
	3443	FABRICATED PLATE WORK	17		
	3451	SCREW MACHINE PRODUCTS	3		
	3452	BOLTS, NUTS, SCREWS, RIVETS AND WASHERS	1		
	3461	METAL STAMPINGS	2		
	3490	MISCELLANEOUS FABRICATED METAL PRODUCTS	2		
	3492	SAFES AND VAULTS	1		
	3494	VALVES & PIPE FITTINGS, EXCEPT PLUMBER'S BRASS GOODS	5		
35		MACHINERY, EXCEPT ELECTRICAL		170	23.2
	3511	ENGINES AND TURBINES (EXCEPT AIRCRAFT)	2		
	3519	INTERNAL COMBUSTION ENGINES	1		
	3522	FARM MACHINERY AND EQUIPMENT	4		
	3531	CONSTRUCTION MACHINERY AND EQUIPMENT	3		
	3533	OIL FIELD MACHINERY AND EQUIPMENT	2		
	3541	MACHINE TOOLS, METAL CUTTING TYPES	55		
	3542	MACHINE TOOLS, METAL FORMING TYPES	2		
	3544	SPECIAL DIES AND TOOLS, DIE SETS, JIGS & FIXTURES	5		
	3545	MACHINE TOOL ACCESSORIES AND MEASURING DEVICES	21		
	3551	FOOD PRODUCTS MACHINERY	2		
	3552	TEXTILE MACHINERY	1		
	3554	PAPER INDUSTRIES MACHINERY	2		
	3555	PRINTING TRADES MACHINERY AND EQUIPMENT	1		
	3561	PUMPS, AIR & GAS COMPRESSORS, & PUMPING EQUIPMENT	4		
	3562	BALL AND ROLLER BEARINGS	5		
	3566	MECHANICAL POWER TRANSMISSION EQUIPMENT, EXCEPT BALL & ROLLER BEARINGS	3		
	3569	GENERAL INDUSTRIAL MACHINERY AND EQUIPMENT	4		
	3571	COMPUTING & ACCOUNTING MACHINES	8		
	3576	SCALES AND BALANCES	3		
	3585	REFRIGERATORS, REFRIGERATION MACHINERY	7		
	3591	MACHINE SHOPS, JOBBING AND REPAIR	25		
	3599	MACHINERY AND PARTS	9		
36		ELECTRICAL MACHINERY, EQUIPMENT AND SUPPLIES		38	5.2
	3611	ELECTRIC MEASURING INSTRUMENTS & TEST EQUIPMENT	3		
	3621	MOTORS AND GENERATORS	4		
	3622	INDUSTRIAL CONTROLS	6		
	3632	HOUSEHOLD REFRIGERATORS & HOME & FARM FREEZERS	1		
	3643	CURRENT CARRYING WIRING DEVICES	4		
	3661	TELEPHONE AND TELEGRAPH APPARATUS	2		
	3662	RADIO AND TELEVISION TRANSMITTING APPARATUS	8		
	3673	TRANSMITTING, INDUSTRIAL, & SPECIAL PURPOSE ELECTRON TUBES	3		
	3679	ELECTRONIC COMPONENTS & ACCESSORIES	5		
	3694	ELECTRICAL EQUIPMENT FOR INTERNAL COMBUSTION ENGINES	1		
	3699	ELECTRICAL MACHINERY, EQUIPMENT & SUPPLIES	1		
37		TRANSPORTATION EQUIPMENT		264	35.9
	3711	MOTOR VEHICLES	7		
	3721	AIRCRAFT AND MISSILES	156		
	3722	AIRCRAFT ENGINES & ENGINE PARTS-MISSILE ENGINES	74		
	3729	AIRCRAFT PARTS & AUXILIARY EQUIPMENT-MISSILE PARTS	27		
38		PROFESSIONAL, SCIENTIFIC, & CONTROLLING INSTRUMENTS; PHOTOGRAPHIC & OPTICAL GOODS; WATCHES & CLOCKS		4	0.5
	3811	ENGINEERING, LABORATORY, SCIENTIFIC INSTRUMENTS	1		
	3821	MECHANICAL MEASURING & CONTROLLING INSTRUMENTS	1		
	3831	OPTICAL INSTRUMENTS & LENSES	1		
	3871	WATCHES, CLOCKS, AND PARTS EXCEPT WATCHCASES	1		
39		MISCELLANEOUS MANUFACTURING INDUSTRIES		2	0.3
	3911	JEWELRY, PRECIOUS METAL	1		
	3964	NEEDLES, PINS, HOOKS & EYES, & SIMILAR NOTIONS	1		

SIC MAJOR GROUP NO.	SIC INDUSTRY NO.		NUMBER OF INQUIRIES		
			BY SIC INDUSTRY NO.	BY SIC MAJOR GROUP NO.	% OF TOTAL
50		WHOLESALE TRADE		11	1.5
	5065	ELECTRONIC PARTS AND EQUIPMENT	1		
	5082	COMMERCIAL & INDUSTRIAL MACHINERY	9		
	5089	MACHINERY, EQUIPMENT & SUPPLIES	1		
52		RETAIL TRADE-BUILDING MATERIALS, HARDWARE & FARM EQUIPMENT		1	0.1
	5251	HARDWARE STORES	1		
73		MISCELLANEOUS BUSINESS SERVICES		28	3.8
	7391	RESEARCH, DEVELOPMENT & TESTING LABORATORIES	27		
	7392	BUSINESS & MANAGEMENT CONSULTING SERVICES	1		
78		MISCELLANEOUS REPAIR SERVICES		1	0.1
	7699	REPAIR SHOPS & RELATED SERVICES	1		
82		EDUCATIONAL SERVICES		25	3.4
	8221	COLLEGES, UNIVERSITIES, & PROFESSIONAL SCHOOLS	25		
86		NONPROFIT MEMBERSHIP ORGANIZATIONS		6	0.8
	8621	PROFESSIONAL MEMBERSHIP ORGANIZATIONS	6		
89		MISCELLANEOUS SERVICES		19	2.6
	8911	ENGINEERING AND ARCHITECTURAL SERVICES	9		
	8921	NONPROFIT EDUCATIONAL AND SCIENTIFIC RESEARCH AGENCIES	10		
01	0001	INDIVIDUALS	1	1	0.1
TOTALS =				738	100.0%

AIR FORCE MACHINABILITY DATA CENTER

GOVERNMENT AGENCIES AND SERVICES SUPPORTED DIRECTLY AND INDIRECTLY BY AFMDC INQUIRIES

February 1, 1966 - January 31, 1967

CATEGORY

A.	TOTAL INQUIRIES FOR THE PERIOD FEBRUARY 1, 1966 THROUGH JANUARY 31, 1967	736
B.	INQUIRIES BY ACADEMIC AND COMMERCIAL SOURCES NOT IDENTIFIABLE WITH GOVERNMENT PURPOSES	17
C.	INQUIRIES IDENTIFIED AS SUPPORTING GOVERNMENT PURPOSES	719
D.	NON-TECHNICAL INQUIRIES (<i>administrative; informational</i>)	8
E.	TECHNICAL INQUIRIES ASSISTING GOVERNMENT PURPOSES	711
F.	DIRECT INQUIRIES BY GOVERNMENT AGENCIES (<i>USAF, NASA, etc.</i>)	42
G.	INQUIRIES BY CONTRACTORS IDENTIFIED DIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (<i>USAF, NASA, etc.</i>)	287
H.	INQUIRIES BY COMPANIES IDENTIFIED INDIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (<i>USAF, NASA, etc.</i>)	382

	AIR FORCE	U.S. NAVY	U.S. ARMY	AEC	NASA	TOTAL
F. DIRECT INQUIRIES BY GOVERNMENT AGENCIES	17	6	11	6	2	42
G. INQUIRIES BY CONTRACTORS IDENTIFIED DIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (<i>USAF, NASA, etc.</i>)	254	2	3	12	16	287
H. INQUIRIES BY COMPANIES IDENTIFIED INDIRECTLY WITH SPECIFIC GOVERNMENT SERVICES OR AGENCIES (<i>USAF, NASA, etc.</i>) TOTAL OF 382; DISTRIBUTION BY RATIO OR PRO- PORTION OF INQUIRIES COUNTED IN G ABOVE.	338	3	4	16	21	382
E. TOTAL TECHNICAL INQUIRIES ASSISTING GOVERNMENT PURPOSES	609	11	16	34	39	711

SUMMARY OF SPECIFIC INQUIRIES BY ALL COMPANIES & AGENCIES

October 1, 1984 - January 31, 1987

ABORN, ROBERT H., MILLINGTON, N.J.
 ACF INDUSTRIES, INC., ALBUQUERQUE, N. MEX.
 ACCURATE BUSHING COMPANY, GARWOOD, N. J.
 ACRALOC CORPORATION, OAK RIDGE, TENN.
 ADAMAS CARBIDE CORPORATION, KENILWORTH, N.J.
 AEROJET-GENERAL CORPORATION, AZUSA, CALIF.
 AEROJET-GENERAL CORPORATION, DOWNEY, CALIF.
 AEROJET-GENERAL CORPORATION, SACRAMENTO, CALIF.
 AEROJET-GENERAL CORPORATION, DAYTON, OHIO
 AERONCA MANUFACTURING CORPORATION, MIDDLETOWN, OHIO
 AEROPROJECTS INC., WEST CHESTER, PA.
 AEROQUIP CORPORATION, VAN WERT, OHIO
 AEROSPACE RESEARCH APPLICATIONS CENTER,
 BLOOMINGTON, IND.
 AIME, NEW YORK, N.Y.
 AIR FORCE HEADQUARTERS, WASHINGTON, D.C.
 AIR FORCE REPRESENTATIVE, THE MARTIN COMPANY,
 DENVER, COLO.
 AIRRESEARCH MANUFACTURING CO., LOS ANGELES, CALIF.
 AIRRESEARCH MANUFACTURING CO., PHOENIX, ARIZ.
 ALLEGANY BALLISTICS LABORATORY, CUMBERLAND, MO.
 ALLEGHENY LUDLUM STEEL CORPORATION, DUNKIRK, N.Y.
 ALLIANCE TOOL CO., INC., ST. LOUIS, MO.
 ALLIED CHEMICAL CORPORATION, MORRISTOWN, N.J.
 ALLIS-CHALMERS MANUFACTURING CO., MILWAUKEE, WISC.
 ALLVAC METALS COMPANY, MONROE, N.C.
 ALUMINUM COMPANY OF AMERICA, PITTSBURGH, PA.
 AMERICAN BOSCH ARMA CORP., SPRINGFIELD, MASS.
 AMERICAN BRAKE SHOE COMPANY, ELYRIA, OHIO
 AMERICAN CYANAMID COMPANY, SANFORD, ME.
 AMERICAN LAUNDRY MACHINERY INDUSTRIES, CINCINNATI, OHIO
 AMERICAN MACHINE & FOUNDRY CO., YORK, PA.
 AMERICAN SAW & MANUFACTURING CO., EAST LONGMEADOW, MASS.
 AMERICAN SOCIETY FOR METALS, METALS PARK, OHIO
 AMERICAN WELDING & MANUFACTURING CO., WARREN, OHIO
 AMES LABORATORY, AMES, IOWA
 ANDERSON BROTHERS MANUFACTURING CO., ROCKFORD, ILL.
 ANDREWS AIR FORCE BASE, WASHINGTON, D.C.
 ANOCUT ENGINEERING COMPANY, ELK GROVE VILLAGE, ILL.
 APEX CORPORATION, BALTIMORE, MD.
 ARGONNE NATIONAL LABORATORY, ARGONNE, ILL.
 ARKWIN INDUSTRIES, INC., WESTUARY, N.Y.
 ARMCO STEEL CORPORATION, BALTIMORE, MD.
 ARMCO STEEL CORPORATION, CINCINNATI, OHIO
 ARMSTRONG BLUM MFG. COMPANY, CINCINNATI, OHIO
 ARMY PROCUREMENT DISTRICT, CHICAGO, ILL.
 ARO, ARNOLD AIR FORCE STATION, TENN.
 ARROW GEAR COMPANY, DOWNERS GROVE, ILL.
 AUTOMATION ACCESSORIES, INC., CINCINNATI, OHIO
 AUTOMATION INDUSTRIES, INC., ABILENE, TEX.
 AVCO CORPORATION, STRATFORD, CONN.
 AVCO CORPORATION, RICHMOND, IND.
 AVCO CORPORATION, WILMINGTON, MASS.
 AVCO CORPORATION, NASHVILLE, TENN.
 AVCO NEW IDEA, COLDWATER, OHIO
 AVEY MACHINE TOOL COMPANY, COVINGTON, KY.
 BADGITT & SMITH ASSOCIATES INC., CINCINNATI, OHIO
 BAKER OIL TOOLS, INC., LOS ANGELES, CALIF.
 BALDWIN-LIMA-HAMILTON, BURNHAM, MIFFLIN COUNTY, PA.
 BATTELLE MEMORIAL INSTITUTE, COLUMBUS, OHIO
 BATTELLE-NORTHWEST LAB., RICHLAND, WASH..
 BAUSCH & LOMB, ROCHESTER, N.Y.
 BDSA, DEPARTMENT OF COMMERCE, WASHINGTON, D.C.
 BELL HELICOPTER COMPANY, FT. WORTH, TEX.
 BELOIT CORPORATION, BELOIT, WISC.
 BELOIT EASTERN CORPORATION, DOWNINGTON, PA.
 BELLOW-SVALVIR CORPORATION, CINCINNATI, OHIO
 BENDIX CORPORATION (THE), KANSAS CITY, MO.
 BENDIX CORPORATION (THE), TETERBORO, N.J.
 BENDIX CORPORATION (THE), YORK, PA.
 BENDIX RESEARCH LABS., SOUTHFIELD, MICH.

BENEDICT-MILLER, INC., LYNDHURST, N.J.
 BENRUS WATCH COMPANY, WATERBURY, CONN.
 BERCO MANUFACTURING COMPANY, WATERBURY, CONN.
 BERYLLIUM CORPORATION (THE), READING, PA.
 BESLY-WELLES CORPORATION, SOUTH BELOIT, ILL.
 BESLY-WELLES CORPORATION, CINCINNATI, OHIO
 BETHLEHEM STEEL CORPORATION, BETHLEHEM, PA.
 BIGGER CO., C. M., READING, OHIO
 BLACK & DECKER MANUFACTURING CO., TOWSON, PA.
 BLISS CO., E. W., SOUTH PORTLAND, ME.
 BOEING COMPANY (THE), WICHITA, KANSAS
 BOEING COMPANY (THE), NEW ORLEANS, LA.
 BOEING COMPANY (THE), RENTON, WASH.
 BOEING COMPANY (THE), SEATTLE, WASH.
 BOMAR COMPANY, CINCINNATI, OHIO
 BOSTROM CORPORATION, MILWAUKEE, WISC.
 BRAD FOOTE GEAR WORKS, INC., CICERO, ILL.
 BRANDS MACHINING CO., PORTLAND, PA.
 BRASS & BRONZE INSTITUTE, CHICAGO, ILL.
 BRIGGS & STRATTON CORP., MILWAUKEE, WISC.
 BRIGHAM YOUNG UNIVERSITY, PROVO, UTAH
 BROOKS & PERKINS INC., DETROIT, MICH.
 BROWN & ROOT, INC., HOUSTON, TEX.
 BRUBAKER TOOL CORPORATION, MILLERSBURG, PA.
 BRUNSWICK CORPORATION, MUSKEGON, MICH.
 BRUSH BERYLLIUM COMPANY (THE), CLEVELAND, OHIO
 BRUSH BERYLLIUM COMPANY (THE), ELMORE, OHIO
 BUERK TOOL & MACHINE CORP., BUFFALO, N.Y.
 BULLARD COMPANY (THE), BRIDGEPORT, CONN.
 BUNKER-RAMO CORPORATION, CLEVELAND, OHIO
 BURGESS-NORTON MANUFACTURING CO., GENEVA, ILL.
 BURGMASER CORPORATION, CINCINNATI, OHIO
 BURNDY CORPORATION, NORWALK, CONN.
 CALIFORNIA GENERAL, INC., CHULA VISTA, CALIF.
 CAMCAR SCREW & MANUFACTURING CO., ROCKFORD, ILL.
 CAMERON IRON WORKS, HOUSTON, TEX.
 CARBORUNDUM COMPANY (THE), NIAGARA FALLS, N.Y.
 CARLISLE CHEMICAL WORKS, INC., READING, OHIO
 CARMET, PITTSBURGH, PA.
 CARNEGIE INSTITUTE OF TECHNOLOGY, PITTSBURGH, PA.
 CARRIER AIR CONDITIONING CO., SYRACUSE, N.Y.
 CATERPILLAR TRACTOR COMPANY, DECATUR, ILL.
 CATERPILLAR TRACTOR COMPANY, PEORIA, ILL.
 CEEMCO, CINCINNATI, OHIO
 CELANESE FIBERS COMPANY, NARROWS, VA.
 CENTRAL FABRICATORS INC., CINCINNATI, OHIO
 CHAMBERS AIRCRAFT, SHELBYVILLE, IND.
 CHANDLER EVANS INC., WEST HARTFORD, CONN.
 CHRYSLER CORPORATION, NEW ORLEANS, LA.
 CHRYSLER CORPORATION, DEARBORN, MICH.
 CHUCKING MACHINE PRODUCTS, INC., FRANKLIN PARK, ILL.
 CINCINNATI LATHE & TOOL CO., CINCINNATI, OHIO
 CINCINNATI MILLING MACHINE CO. (THE), CINCINNATI, OHIO
 CINCINNATI MINE MACHINERY COMPANY, CINCINNATI, OHIO
 CINCINNATI SHAPER COMPANY, WHITEWATER, OHIO
 CINCINNATI, UNIVERSITY OF, CINCINNATI, OHIO
 CLEARINGHOUSE FOR FEDERAL SCIENTIFIC & TECHNICAL
 INFORMATION, SPRINGFIELD, MO.
 CLEVELAND PNEUMATIC TOOL CO. (THE), CLEVELAND, OHIO
 CLEVELAND TWIST DRILL COMPANY, CLEVELAND, OHIO
 COBALT INFORMATION CENTER, COLUMBUS, OHIO
 COLLINS RADIO COMPANY, CEDAR RAPIDS, IOWA
 COLLINS RADIO COMPANY, DALLAS, TEX.
 COLT INDUSTRIES INC., BELOIT, WISC.
 CONCORD-RENN COMPANY, CINCINNATI, OHIO
 CONTINENTAL AVIATION & ENGINEERING, DETROIT, MICH.
 CONTINENTAL COPPER & STEEL CO., BRAEBURN, PA.
 CONTINENTAL-EMSCO CO., GARLAND, TEX.
 CONVER STEEL & WIRE CO. INC., NEW YORK, N.Y.
 COORS CO., INC., H.F., INGLEWOOD, CALIF.
 CORNHART REFRACTORIES CO., BUCKHANNON, W. VA.

CORNELL AERONAUTICAL LAB. INC., BUFFALO, N.Y.
 CORNING GLASS WORKS, CORNING, N.Y.
 CORPLAN ASSOCIATES, CHICAGO, ILL.
 CRAFTNEEDS INC., CINCINNATI, OHIO
 CRANE, NEW CASTLE, PA.
 CRUCIBLE STEEL CO. OF AMERICA, PITTSBURGH, PA.
 CRUCIBLE STEEL CO. OF AMERICA, CINCINNATI, OHIO
 CUMMINS ENGINE COMPANY, INC., COLUMBUS, IND.
 CURTISS-WRIGHT CORP., CALDWELL, N.J.
 CURTISS-WRIGHT CORP., WOOD-RIDGE, N.J.
 CURTISS-WRIGHT CORP., BUFFALO, N.Y.
 CUSTOM TOOLING COMPANY, CINCINNATI, OHIO

DALMO VICTOR COMPANY, BELMONT, CALIF.
 DATA INFORMATION GATHERING SERVICE, PALO ALTO, CALIF.
 DAVEWOOD SUPPLY COMPANY, ROCKFORD, ILL.
 DAYTON RESEARCH INSTITUTE, UNIVERSITY OF, DAYTON, OHIO
 DEERE & COMPANY, MOLINE, ILL.
 DEL MACHINE & WELDING WORKS, INC., HOUSTON, TEX.
 DETROIT BROACH & MACHINE COMPANY, ROCHESTER, MICH.
 DEUTSCH COMPANY, LOS ANGELES, CALIF.
 DIAMOND ALKALI COMPANY, PAYNESVILLE, OHIO
 DIAMONITE PRODUCTS MANUFACTURING COMPANY, SHREVE, OHIO
 D-K PRODUCTS, CHICAGO, ILL.
 D-M-E CORPORATION, DETROIT, MICH.
 DOUGLAS AIRCRAFT CO., INC., SANTA MONICA, CALIF.
 DOUGLAS AIRCRAFT CO., INC., LONG BEACH, CALIF.
 DOW CHEMICAL COMPANY (THE), DENVER, COLO.
 DOW CHEMICAL COMPANY (THE), GOLDEN, COLO.
 DOW CHEMICAL COMPANY (THE), MIDLAND, MICH.
 DREW CHEMICAL CORPORATION, BOONTON, N.J.
 DREXEL INSTITUTE OF TECHNOLOGY, PHILADELPHIA, PA.
 DUPONT DENEMOURS & CO., E.I., WILMINGTON, DEL.

EATON MANUFACTURING CO., SOUTH EUCLID, OHIO
 EDMUNDS MANUFACTURING COMPANY, FARMINGTON, CONN.
 EIS AUTOMOTIVE CORPORATION (THE), MIDDLETOWN, CONN.
 EITEL-MCCULLOUGH, INC., SAN CARLOS, CALIF.
 ELAND CORPORATION, XENIA, OHIO
 ELASTIC STOP-NUT CORP. OF AMERICA, UNION, N.J.
 ELECTRIC STORAGE BATTERY CO. (THE), PHILADELPHIA, PA.
 ELECTRICAL MACHINING INC., CINCINNATI, OHIO
 ELECTRONIC SPECIALTY CO., PORTLAND, OREG.
 ELLIOTT COMPANY, JEANNETTE, PA.
 ELOX CORPORATION OF MICHIGAN, TROY, MICH.
 ERIE INDUSTRIES, INC., FERRDALE, MICH.
 ERNST, HANS, CLEARWATER, FLA.
 EUCLID MACHINE COMPANY INC., INDIANAPOLIS, IND.
 EX-CELL-O CORPORATION, LIMA, OHIO

FAIRCHILD HILLER CORPORATION, ROCKVILLE, MO.
 FAIRCHILD HILLER CORPORATION, FARMINGDALE, L.I., N.Y.
 FAIRCHILD PRECISION METALS PRODUCTS, EL CAJON, CALIF.
 FANSTEEL METALLURGICAL CORP., NO. CHICAGO, ILL.
 FIBERITE CORPORATION, WINONA, MINN.
 FIRESTONE TIRE & RUBBER CO. (THE), AKRON, OHIO
 FIRTH STERLING INC., PITTSBURGH, PA.
 FISCHER GOVERNOR COMPANY, MARSHALLTOWN, IOWA
 FORD MOTOR COMPANY, DEARBORN, MICH.
 FORD MOTOR COMPANY, LIVONIA, MICH.
 FORD MOTOR COMPANY, CINCINNATI, OHIO
 FRANKFORD ARSENAL, PHILADELPHIA, PA.
 FRANKLIN BALMAR CORPORATION, BALTIMORE, MD.
 FRANKLIN ELECTRIC CO., INC., BLUFFTON, IND.
 FULLER MERRIAM COMPANY, WEST HAVEN, CONN.
 FYR-FYTER COMPANY (THE), NEWARK, N.J.

G&O TOOL & DIE COMPANY, BEECHGROVE, IND.
 G&M COMPANY, KENNETH J., INDIANAPOLIS, IND.
 GARDNER MACHINE COMPANY, SOUTH BELOIT, ILL.
 GENERAL DYNAMICS CORPORATION, SAN DIEGO, CALIF.
 GENERAL DYNAMICS CORPORATION, GROTON, CONN.
 GENERAL DYNAMICS CORPORATION, FT. WORTH, TEX.
 GENERAL DYNAMICS CORPORATION, NEW YORK, N.Y.

GENERAL ELECTRIC COMPANY, CINCINNATI, OHIO
 GENERAL ELECTRIC COMPANY, SCHENECTADY, N.Y.
 GENERAL ELECTRIC COMPANY, EVERETT, MASS.
 GENERAL ELECTRIC COMPANY, LYNN, MASS.
 GENERAL ELECTRIC COMPANY, PHILADELPHIA, PA.
 GENERAL ELECTRIC COMPANY, DAYTON, OHIO
 GENERAL ELECTRIC COMPANY, BURLINGTON, VT.
 GENERAL ELECTRIC COMPANY, PHOENIX, ARIZ.
 GENERAL ELECTRIC COMPANY, PLEASANTOWN, CALIF.
 GENERAL ELECTRIC COMPANY, SAN JOSE, CALIF.
 GENERAL ELECTRIC COMPANY, BLOOMINGTON, ILL.
 GENERAL ELECTRIC COMPANY, FT. WAYNE, IND.
 GENERAL ELECTRIC COMPANY, LOUISVILLE, KY.
 GENERAL ELECTRIC COMPANY, WARREN, MICH.
 GENERAL ELECTRIC COMPANY, DETROIT, MICH.
 GENERAL ELECTRIC COMPANY, UTICA, N.Y.
 GENERAL ELECTRIC COMPANY, CLEVELAND, OHIO
 GENERAL ELECTRIC COMPANY, ERIE, PA.
 GENERAL ELECTRIC COMPANY, SYRACUSE, N.Y.
 GENERAL ELECTRIC COMPANY, RUTLAND, VT.
 GENERAL ELECTRIC COMPANY, VALLEY FORGE SPACE TECHNOLOGY CENTER, PHILADELPHIA, PA.
 GENERAL MOTORS CORPORATION, WARREN, MICH.
 GENERAL MOTORS CORPORATION, ANDERSON, IND.
 GENERAL MOTORS CORPORATION, FRIGIDAIRE DIVISION, DAYTON, OHIO
 GENERAL MOTORS CORPORATION, INLAND MANUFACTURING DIVISION, DAYTON, OHIO
 GENERAL MOTORS CORPORATION, INDIANAPOLIS, IND.
 GENERAL MOTORS DEFENSE RESEARCH LAB., SANTA BARBARA, CALIF.
 GENERAL MOTORS INSTITUTE, FLINT, MICH.
 GENERAL PRECISION, INC., BINGHAMTON, N.Y.
 GENERAL PRECISION AEROSPACE, TECHNICAL INFORMATION CENTER, LITTLE FALLS, N.J.
 GISHOLT CORPORATION, MADISON, WISC.
 GLIDDEN COMPANY (THE), BALTIMORE, MD.
 GOLDMAN & COMPANY, HARVEY, DEARBORN, MICH.
 GOODYEAR AEROSPACE CORPORATION, AKRON, OHIO
 GOULDS PUMPS, INC., SENECA FALLS, N.Y.
 GRAHAM RESEARCH LABORATORY, PITTSBURGH, PA.
 GRAY CO., G.A., CINCINNATI, OHIO
 GREAT LAKES RESEARCH CORP., ELIZABETHTON, TENN.
 GREENFIELD TAP & DIE COMPANY, GREENFIELD, MASS.
 GREENLEAF CORPORATION, HAGERSTOWN, PA.
 GRIKO CHEMICAL PRODUCTS, INC., NEWARK, N.J.
 GRUMMAN AIRCRAFT ENGINEERING CORP., BETHPAGE, L.I., N.Y.

H&C SUPPLY CORPORATION, ROCHESTER, N.Y.
 HAMILTON STANDARD, WINDSOR LOCKS, CONN.
 HAMILTON TOOL & MACHINE CO., KENILWORTH, N.J.
 HARNISCHFEGGER COMPANY, ESCANABA, MICH.
 HARRIS-INTERTYPE CORPORATION, CLEVELAND, OHIO
 HARVARD BUSINESS SCHOOL, CAMBRIDGE, MASS.
 HARVEY ALUMINUM SALES INC., EAST ORANGE, N.J.
 HASTINGS MANUFACTURING CO., HASTINGS, MICH.
 HATER INDUSTRIES, CINCINNATI, OHIO
 HEALD MACHINE COMPANY, WORCESTER, MASS.
 HERKERT PRODUCTS COMPANY, CHICAGO, ILL.
 HILL, GEORGE M., OXFORD, OHIO
 HIRSCHMANN CORPORATION, ROSLYN HEIGHTS, N.Y.
 HOBART MANUFACTURING COMPANY, TROY, OHIO
 HOFFMAN BROTHERS JEWELRY COMPANY, TUNXSUTAWNEY, PA.
 HOLLEY CARBURETOR COMPANY, WARREN, MICH.
 HONEYWELL INC., ST. PETERSBURG, FLA.
 HONEYWELL INC., NEW BRIGHTON, MINN.
 HOUGHTON COMPANY, E.F., CINCINNATI, OHIO
 HOUSTON, UNIVERSITY OF, HOUSTON, TEX.
 HUGHES AIRCRAFT COMPANY, CULVER CITY, CALIF.
 HUGHES AIRCRAFT COMPANY, EL SEGUNDO, CALIF.
 HYDRAULIC RESEARCH & MANUFACTURING COMPANY, BURBANK, CALIF.
 HYSTER COMPANY, PORTLAND, OREG.

IIT RESEARCH INSTITUTE, CHICAGO, ILL.
 ITT CANNON ELECTRIC INC., LOS ANGELES, CALIF.
 ILLINOIS INSTITUTE OF TECHNOLOGY, CHICAGO, ILL.
 ILLINOIS, UNIVERSITY OF, URBANA, ILL.
 INGERSOLL MILLING MACHINE CO. (THE), ROCKFORD, ILL.
 INGERSOLL-RAND COMPANY, PRINCETON, N.J.
 INGERSOLL-RAND COMPANY, PAINTED POST, N.Y.
 INGERSOLL-RAND COMPANY, PHILLIPSBURG, N.J.
 INSTITUTE OF GAS TECHNOLOGY, CHICAGO, ILL.
 INTERNATIONAL BUSINESS MACHINES CORP., ROCKVILLE, MD.
 INTERNATIONAL BUSINESS MACHINES CORP., OWEGA, N.Y.
 INTERNATIONAL BUSINESS MACHINES CORP., KINGSTON, N.Y.
 INTERNATIONAL BUSINESS MACHINES CORP., ENDICOTT, N.Y.
 INTERNATIONAL BUSINESS MACHINES CORP., LEXINGTON, KY.
 INTERNATIONAL BUSINESS MACHINES CORP., Poughkeepsie, N.Y.
 INTERNATIONAL BUSINESS MACHINES CORP., DAYTON, OHIO
 INTERNATIONAL HARVESTER CO., CHICAGO, ILL.
 INTERNATIONAL LEAD ZINC RESEARCH ORGANIZATION INC.,
 NEW YORK, N.Y.

INTERNATIONAL NICKEL CO., INC. (THE), NEW YORK, N.Y.
 INTERNATIONAL NICKEL CO., INC. (THE), SUFFERN, N.Y.
 INTERNATIONAL NICKEL CO., INC. (THE), DAYTON, OHIO
 INTERNATIONAL NICKEL CO., INC. (THE), HUNTINGTON, W.VA.
 ION PHYSICS CORPORATION, BURLINGTON, MASS.
 IOWA, UNIVERSITY OF, IOWA CITY, IOWA
 IRON AGE, PHILADELPHIA, PA.

JANSSEN MANUFACTURING COMPANY, WAYNESVILLE, OHIO
 JARVIS CORP., GREENWOOD, S.C.
 JARVIS CORP., PORTLAND, CONN.
 JERDEN MANUFACTURING COMPANY, INDIANAPOLIS, IND.
 JONES & LAMSON, SPRINGFIELD, VA.
 JONES & LAUGHLIN STEEL CORP., INDIANAPOLIS, IND.

KDI COMPANY, CINCINNATI, OHIO
 KANSAS STATE COLLEGE OF PITTSBURGH, PITTSBURGH, PA.
 KARL AND SONS, WILLIAM, MIDDLE VILLAGE, L.I., N.Y.
 KEARNEY & CO., INC., A.T., CHICAGO, ILL.
 KEARNEY & TRECKER, MILWAUKEE, WISC.
 KENAMETAL, INC., CINCINNATI, OHIO
 KENAMETAL, INC., LATROBE, PA.
 KERNS MANUFACTURING COMPANY, LONG ISLAND CITY, N.Y.
 KING FIFTH WHEEL COMPANY, MOUNTAINTOP, PA.
 KINSEY CO., E.A., CINCINNATI, OHIO
 KLIK INDUSTRIES, HARTFORD, CONN.
 KOEHRING CO., HPM DIVISION, MT. GILEAD, OHIO
 KOPPERS COMPANY INC., BALTIMORE, MD.
 KREISLER INDUSTRIAL CORP., EAST PATERSON, N.J.
 KRESS CORPORATION, CLEVELAND, OHIO
 KRONENBERG, DR. MAX, CINCINNATI, OHIO
 KUNTZ CO., J.R., DAYTON, OHIO

LTV ELECTROSYSTEMS, INC., GREENVILLE, TEX.
 LADISH COMPANY, CUDAHY, WISC.
 LATROBE STEEL COMPANY, LATROBE, PA.
 LAWRENCE RADIATION LABORATORY, LIVERMORE, CALIF.
 LEAR SIEGLER COMPANY, GRAND RAPIDS, MICH.
 LEBANON STEEL FOUNDRY, LEBANON, PA.
 LEBLOND TOOL COMPANY, R.K., CINCINNATI, OHIO
 LEHIGH UNIVERSITY, BETHLEHEM, PA.
 LENNOR ENGINEERING COMPANY, CHICAGO, ILL.
 LESSLETS AND ASSOCIATES, WALTHAM, MASS.
 LING-TEYCO-VOUGHT, INC., DALLAS, TEX.
 LINK BELT COMPANY, INDIANAPOLIS, IND.
 LINK BELT COMPANY, PHILADELPHIA, PA.
 LITTLE CO. INC., ARTHUR D., CAMBRIDGE, MASS.
 LLOYD PRODUCTS COMPANY, CINCINNATI, OHIO
 LOCKHEED AIRCRAFT CORPORATION, BURBANK, CALIF.
 LOCKHEED AIRCRAFT CORPORATION, SUNNYVALE, CALIF.
 LOCKHEED-GEORGIA COMPANY, MARIETTA, GA.
 LOCKHEED MISSILES & SPACE CO., PALO ALTO, CALIF.
 LOCKHEED PROPULSION COMPANY, REDLANDS, CALIF.
 LONGYEAR COMPANY, E.J., MINNEAPOLIS, MINN.
 LORD MANUFACTURING COMPANY, ERIE, PA.

LOUD COMPANY, H.W., POMONA, CALIF.
 LUBRX PRODUCTS INC., NORTH ATTLEBORO, MASS.
 LUNKENHEIMER COMPANY, CINCINNATI, OHIO

MS&R INC., IRWIN, PA.
 MACHINECRAFT, INC., BALTIMORE, MD.
 MACHINERY, BIRMINGHAM, MICH.
 MACHINING TECHNOLOGY CORPORATION, SO. WINDSOR, CONN.
 MACKLIN COMPANY, JACKSON, MICH.
 MADISON INDUSTRIES, PROVIDENCE, R.I.
 MAFFITT TOOL & MACHINE CO., ST. LOUIS, MO.
 MAGNA MACHINE COMPANY, CINCINNATI, OHIO
 MANHATTAN RAYBESTOS, CORINTH, KY.
 MANSFIELD PHOTO ENGRAVING, MANSFIELD, OHIO
 MAREMONT COMPANY, SACO, ME.
 MARLIN ROCKWELL COMPANY, PLAINVILLE, CONN.
 MARQUARDT CORPORATION (THE), VAN NUYS, CALIF.
 MARQUARDT CORPORATION (THE), OGDEN, UTAH
 MARTIN COMPANY, ORLANDO, FLA.
 MARTIN COMPANY, BALTIMORE, MD.
 MARTIN COMPANY, DENVER, COLO.
 MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASS.
 MASTER CHEMICAL CORPORATION, PERRYSBURG, OHIO
 MATERIALS IN DESIGN ENGINEERING, NEW YORK, N.Y.
 MATERIALS DEVELOPMENT, INC., PROSPECT, KY.
 MATERIALS TESTING LABORATORY, LOS ANGELES, CALIF.
 MAYNARD AND COMPANY INC., H.B., PITTSBURGH, PA.
 MEAD CORPORATION, CINCINNATI, OHIO
 MEASUREGRAPH COMPANY (THE), ST. LOUIS, MO.
 MECHANICAL SUPPLIES COMPANY, CINCINNATI, OHIO
 MELPAR MATERIALS INFORMATION CENTER, KENNEDY SPACE
 CENTER, FLA.

MENASCO MANUFACTURING COMPANY, FT. WORTH, TEX.
 MERCER ALLOYS CORPORATION, GREENVILLE, PA.
 MERCER MACHINE COMPANY, INDIANAPOLIS, IND.
 METAL FINISHING SERVICE, CHICAGO, ILL.
 METAL LUBRICANTS COMPANY, CHICAGO, ILL.
 METAL MATIC INC., SOUTH BEND, IND.
 METAL POWDER INDUSTRIES FEDERATION, NEW YORK, N.Y.
 METALWORKING MAGAZINE, BOSTON, MASS.
 METALWORKING NEWS, CINCINNATI, OHIO
 METCUT RESEARCH ASSOCIATES INC., CINCINNATI, OHIO
 METEM CORPORATION, HANOVER, N.J.
 MIDWEST RESEARCH INSTITUTE, KANSAS CITY, MO.
 MINIATURE PRECISION BEARINGS, INC., KEENE, N.H.
 MINNESOTA MINING & MANUFACTURING CO., ST. PAUL, MINN.
 MISSISSIPPI STATE UNIVERSITY, GULFPORT, MISS.
 MONSANTO RESEARCH CORPORATION, MIAMISBURG, OHIO
 MONSANTO RESEARCH CORPORATION, DAYTON, OHIO
 MONTGOMERY CO., H.A., DETROIT, MICH.
 MOREHEAD STATE UNIVERSITY, MOREHEAD, KY.
 MORFORM TOOL COMPANY, CINCINNATI, OHIO
 MORRIS & COMPANY, E.K., CINCINNATI, OHIO
 MORWEAR TOOLS INC., CINCINNATI, OHIO
 MOSLER LOCK COMPANY, MILFORD, OHIO

MCCULLOCH CORPORATION, LOS ANGELES, CALIF.
 McDONNELL AIRCRAFT CORPORATION, ST. LOUIS, MO.
 MCGREGOR MANUFACTURING CORP., TROY, MICH.
 McMELLON BROTHERS, INC., BRIDGEPORT, CONN.

NASA, BETHESDA, MD.
 NASA LEWIS RESEARCH CENTER, CLEVELAND, OHIO
 NASA SCIENTIFIC & TECHNICAL INFORMATION FACILITY,
 COLLEGE PARK, MD.
 NATIONAL CASH REGISTER COMPANY, DAYTON, OHIO
 NATIONAL FORGE COMPANY, IRVINE, WARREN COUNTY, PA.
 NATIONAL LEAD CO. OF OHIO, CINCINNATI, OHIO
 NATIONAL LEAD CO. OF OHIO, FERNALD, OHIO
 NATIONAL SCREW MACHINE PRODUCTS ASSOCIATION, CLEVELAND,
 OHIO
 NATIONAL WATER LIFT COMPANY, KALAMAZOO, MICH.
 NELCO CUTTER COMPANY, MANCHESTER, CONN.
 NEUMAN AND COMPANY, H., SKOKIE, ILL.

NEVILL, C.R., INDIANAPOLIS, IND.
 NEW BRITAIN MACHINE CO. (THE), NEW BRITAIN, CONN.
 NEW ENGLAND METALLURGICAL CORPORATION, SO. BOSTON, MASS.
 NORDEN COMPANY, NORWALK, CONN.
 NORTH AMERICAN AVIATION, INC., ANAHEIM, CALIF.
 NORTH AMERICAN AVIATION, INC., TULSA, OKLA.
 NORTH AMERICAN AVIATION, INC., CANOGA PARK, CALIF.
 NORTH AMERICAN AVIATION, INC., COLUMBUS, OHIO
 NORTH AMERICAN AVIATION, INC., LOS ANGELES, CALIF.
 NORTH AMERICAN AVIATION, INC., INGLEWOOD, CALIF.
 NORTH AMERICAN AVIATION, INC., EL SEGUNDO, CALIF.
 NORTHROP NORAIR, HAWTHORNE, CALIF.
 NORTHROP VENTURA, NEWBURY PARK, CALIF.
 NORTON COMPANY, WORCESTER, MASS.
 NUCLEAR METALS, INC., WEST CONCORD, MASS.
 NU TEC ENGINEERING CORPORATION, WARREN, MICH.
 NU-TOOL SAW SERVICE, INC., DETROIT, MICH.

OK TOOL COMPANY, INC., MILFORD, N.H.
 OPW, CINCINNATI, OHIO
 OAKES CORPORATION, E.T. (THE), LONG ISLAND, N.Y.
 OBERG MANUFACTURING COMPANY, INC., FREEPORT, PA.
 OHIO STATE UNIVERSITY (THE), COLUMBUS, OHIO
 OKLAHOMA STATE UNIVERSITY, STILLWATER, OKLA.
 ONTARIO CORPORATION, MUNCIE, IND.
 OREGON TECHNICAL INSTITUTE, KLAMATH FALLS, OREG.

PACKER CONSULTING ASSOCIATES, NAPERVILLE, ILL.
 PANDA PRODUCTS, CINCINNATI, OHIO
 PECK, PAUL H., BROCKTON, MASS.
 PENN NUCLEAR CORPORATION, PENN, PA.
 PENNSYLVANIA STATE UNIVERSITY, UNIVERSITY PARK, PA.
 PENTA TECHNICAL COLLEGE, PERRYSBURG, OHIO
 PESCO PRODUCTS, BEDFORD, OHIO
 PHILADELPHIA NAVAL SHIPYARD, PHILADELPHIA, PA.
 PHILCO CORPORATION, LAWDALE, CALIF.
 PICATINNY ARSENAL, DOVER, N.J.
 PIPE MACHINERY COMPANY, CLEVELAND, OHIO
 PITTSBURGH PLATE GLASS CO., PITTSBURGH, PA.
 PLANET PRODUCTS CORP., CINCINNATI, OHIO
 POLYMET CORPORATION, CINCINNATI, OHIO
 PRATT & WHITNEY AIRCRAFT, WEST PALM BEACH, FLA.
 PRATT & WHITNEY AIRCRAFT, EAST HARTFORD, CONN.
 PRECISION CASTPARTS CORPORATION, PORTLAND, OREG.
 PRESTOLITE CO. (THE), DECATUR, ALA.
 PRISOCK ASSOCIATES, JOHN, CINCINNATI, OHIO
 PROCTER & GAMBLE CO., CINCINNATI, OHIO
 PRUYNE COMPANY, SAN DIEGO, CALIF.
 PURDUE UNIVERSITY, WEST LAFAYETTE, IND.

RCA LABORATORIES, PRINCETON, N.J.
 RADIO CORPORATION OF AMERICA, LANCASTER, PA.
 RADIO CORPORATION OF AMERICA, CAMDEN, N.J.
 RAYTHEON COMPANY, WALTHAM, MASS.
 RAYTHEON COMPANY, WAYLAND, MASS.
 RAYTHEON COMPANY, BRISTOL, TENN.
 REACTIVE METALS, INC., NILES, OHIO
 REDSTONE ARSENAL, REDSTONE ARSENAL, ALA.
 REPUBLIC STEEL CORPORATION, CLEVELAND, OHIO
 RESOURCES DEVELOPMENT CORP., E. LANSING, MICH.
 REX CHAINBELT INC., DOWNERS GROVE, ILL.
 REYNOLDS METALS COMPANY, RICHMOND, VA.
 ROCK ISLAND ARSENAL, ROCK ISLAND, ILL.
 ROHR CORPORATION, CHULA VISTA, CALIF.
 ROLLWAY BEARING CO., LIVERPOOL, N.Y.
 ROMA CORPORATION, INDIANAPOLIS, IND.
 ROOTS-CONNERSVILLE BLOWER DIV., CONNERSVILLE, IND.
 RYERSON & SON, INC., JOS T., CHICAGO, ILL.

S&S MACHINERY COMPANY, BROOKLYN, N.Y.
 SAE STEELS, INC., HUDSON, OHIO
 ST. JOSEPH LEAD COMPANY, MONACA, PA.
 SANDIA CORPORATION, ALBUQUERQUE, N.M.
 SATEC CORPORATION, GROVE CITY, PA.

SAUNDERS & CO. INC., ALEXANDER, COLD SPRING, N.Y.
 SCHELLENS TRUE CORPORATION, IVORYTON, CONN.
 SEATTLE UNIVERSITY, SEATTLE, WASH.
 SECTO INDUSTRIES INC., CINCINNATI, OHIO
 SEYBOLD COMPANY, CINCINNATI, OHIO
 SHEAFFER PEN COMPANY, W.A., FT. MADISON, IOWA
 SHEFFIELD CORPORATION (THE), DAYTON, OHIO
 SHWAYDER CHEMICAL METALLURGY CORP., DETROIT, MICH.
 SMALL BUSINESS ADMINISTRATION, CHICAGO, ILL.
 SNAP-ON-TOOLS COMPANY, KENOSHA, WISC.
 SONNET TOOL & MFG. CO., HAWTHORNE, CALIF.
 SOUTH CHESTER CORPORATION, LESTER, PA.
 SOUTH SHORE TOOL & DEVELOPMENT INC., MENTOR, OHIO
 SOUTHWEST RESEARCH INSTITUTE, SAN ANTONIO, TEX.
 SPERRY-FARRAGUT COMPANY, BRISTOL, TENN.
 SPERRY MICROWAVE ELECTRONICS COMPANY, CLEARWATER, FLA.
 SPINDLETOP RESEARCH, LEXINGTON, KY.
 SPRINGFIELD ARMORY, SPRINGFIELD, MASS.
 STANDARD OIL COMPANY (THE), CLEVELAND, OHIO
 STANDARD PRESSED STEEL CO., JENKINTOWN, PA.
 STARK INDUSTRIAL SUPPLY COMPANY, CANTON, OHIO
 STEEL MAGAZINE, CLEVELAND, OHIO
 STERLING GRINDING WHEEL CO., TIFFIN, OHIO
 STERLING INSTRUMENT, MINEOLA, N.Y.
 STEVENS INSTITUTE OF TECHNOLOGY, HOBOKEN, N.J.
 STRASMAN MACHINERY CORPORATION, LONG BEACH, CALIF.
 STUART OIL CO., LTD., D.A., CHICAGO, ILL.
 SUNDSTRAND AVIATION, ROCKFORD, ILL.
 SUN OIL COMPANY, MARCUS HOOK, PA.
 SUN SHIPBUILDING & DRY DOCK CO., CHESTER, PA.
 SYLVESTER SCREW COMPANY, PROVIDENCE, R.I.

TRW INC., CLEVELAND, OHIO
 TECUMSEH PRODUCTS COMPANY, ANN ARBOR, MICH.
 TELEDYNE, INC., CHARLOTTEVILLE, VA.
 TELEFLEX INC., NORTH WALES, PA.
 TELETYPE CORPORATION, SKOKIE, ILL.
 TENNESSEE, UNIVERSITY OF, KNOXVILLE, TENN.
 TEXACO INC., BEACON, N.Y.
 TEXACO INC., CINCINNATI, OHIO
 TEXAS INSTRUMENTS INC., DALLAS, TEX.
 TEXAS, UNIVERSITY OF, AUSTIN, TEX.
 THERM INC., ITHACA, N.Y.
 THIOKOL CHEMICAL CORPORATION, DENVER, N.J.
 TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO
 TINKER AIR FORCE BASE, OKLAHOMA
 TIPP MACHINE & TOOL INC., TIPP CITY, OHIO
 TITANIUM METALS CORP. OF AMERICA, NEW YORK, N.Y.
 TITANIUM METALS CORP. OF AMERICA, TORONTO, OHIO
 TOOL SALES & SERVICE, CINCINNATI, OHIO
 TOWNSEND COMPANY, SANTA ANA, CALIF.
 TRI-D CORPORATION, PLAINVILLE, CONN.
 TRU-CUT MACHINE CORPORATION, FAIRFAX, OHIO
 TYLER CORPORATION, BENSON, MINN.

UTD CORPORATION, ATHOL, MASS.
 U.S. ARMY, FT. BELVOIR, VA.
 U.S. ARMY EDGEWOOD ARSENAL, EDGEWOOD ARSENAL, MD.
 U.S. ARMY MISSILE COMMAND PROJECT OFFICE, QUEBEC, CANADA
 U.S. ARMY PRODUCTION EQUIPMENT AGENCY, ROCK ISLAND, ILL.
 U.S. ARMY WEAPONS COMMAND, ROCK ISLAND, ILL.
 U.S. ATOMIC ENERGY COMMISSION, WASHINGTON, D.C.
 U.S. BORAX & CHEMICAL CORP., NEW YORK, N.Y.
 U.S. ELECTRICAL MOTORS, LOS ANGELES, CALIF.
 U.S. NAVAL AVIONICS FACILITY, INDIANAPOLIS, IND.
 U.S. NAVAL ORDNANCE LAB., WHITE OAK, MD.
 U.S. NAVAL ORDNANCE TEST STATION, CHINA LAKE, CALIF.
 U.S. STEEL CORPORATION, MONROEVILLE, PA.
 UNION CARBIDE CORPORATION, OAK RIDGE, TENN.
 UNION CARBIDE CORPORATION, KOKOMO, IND.
 UNION CARBIDE CORPORATION, INDIANAPOLIS, IND.
 UNION CARBIDE CORPORATION, OAK RIDGE NATIONAL LAB., OAK RIDGE, TENN.
 UNION CARBIDE NUCLEAR CORP., PADUCAH, KY.

UNITED AIRCRAFT CORPORATE SYSTEMS CENTER,
FARMINGTON, CONN.
UNITED AIR LINES, SAN FRANCISCO, CALIF.
UNITED TECHNOLOGY CENTER, SUNNYVALE, CALIF.
UNIVERSAL-CYCLOPS SPECIALTY STEEL, BRIDGEVILLE, PA.
UTAH STATE UNIVERSITY, LOGAN, UTAH

V.I. JEWELRY MANUFACTURING CORPORATION, NEW YORK, N.Y.
VALENITE METALS, INDIANAPOLIS, IND
VALERON CORPORATION (THE), DAYTON, OHIO
VAN STRAATEN CHEMICAL COMPANY, CHICAGO, ILL.
VASCO METALS CORPORATION, LATROBE, PA.
VEEDER-ROOT INC., ALTOONA, PA.
VICKERS INC., DETROIT, MICH.
VICKERS INC., TROY, MICH.
VICKERS INC., JACKSON, MISS.
VINCO CORPORATION, DETROIT, MICH.
VIRGINIA POLYTECHNIC INSTITUTE, BLACKSBURG, VA.
VITRO LABORATORIES, WEST ORANGE, N.J.
VOGT MACHINE CO., INC., HENRY, LOUISVILLE, KY.

WAH CHANG CORPORATION, GLEN COVE, N.Y.
WALKER CO., INC., O.S., WORCESTER, MASS.
WALMET CORPORATION (THE), PLEASANT RIDGE, MICH.
WALTCO ENGINEERING CO., GARDENA, CALIF.
WARNER & SWASEY COMPANY (THE), CLEVELAND, OHIO
WARNER & SWASEY COMPANY (THE), LAHR DIVISION,
CLEVELAND, OHIO
WARREN PUMPS, INC., WARREN, MASS.
WATERTOWN ARSENAL, WATERTOWN, MASS.

WATERVLIET ARSENAL, WATERVLIET, N.Y.
WAYNE STATE UNIVERSITY, DETROIT, MICH.
WEATHERHEAD COMPANY (THE), DAYTON, OHIO
WEBCO MACHINE PRODUCTS, INC., CLEVELAND, OHIO
WEINMAN PUMP MANUFACTURING CO. (THE), COLUMBUS, OHIO
WEST MILTON PRECISION TOOL COMPANY, VANDALIA, OHIO
WESTERN ELECTRIC CO., INC., NEW YORK, N.Y.
WESTERN ELECTRIC CO., INC., OMAHA, NEBR.
WESTERN ELECTRIC CO., INC., PRINCETON, N.J.
WESTERN GEAR CORPORATION, EVERETT, WASH.
WESTERN RESERVE UNIVERSITY, CLEVELAND, OHIO
WESTINGHOUSE ELECTRIC CORP., PITTSBURGH, PA.
WESTINGHOUSE ELECTRIC CORP., PHILADELPHIA, PA.
WESTINGHOUSE ELECTRIC CORP., HOMERWOOD, PA.
WESTINGHOUSE ELECTRIC CORP., SUNNYVALE, CALIF.
WHITIN MACHINE WORKS, WHITINSVILLE, MASS.
WHITTAKER CORPORATION, LA MESA, CALIF.
WISCONSIN STATE UNIVERSITY, PLATTEVILLE, WISC.
WITHROW COMPANY, ARTHUR C., LOS ANGELES, CALIF.
WORLD TOOL & ENGINEERING COMPANY, MINNEAPOLIS, MINN.
WRIGHT-PATTERSON AIR FORCE BASE, MANUFACTURING TECHNOLOGY
DIVISION, WRIGHT-PATTERSON AFB, OHIO
WYMAN-GORDON COMPANY, WORCESTER, MASS.
WYMAN-GORDON COMPANY, NORTH GRAFTON, MASS.

XEROX CORPORATION, ROCHESTER, N.Y.

ZIMNEY CORPORATION, MONROVIA, CALIF.

SUMMARY OF SPECIFIC INQUIRIES BY COMPANIES MAKING 4 OR MORE REQUESTS

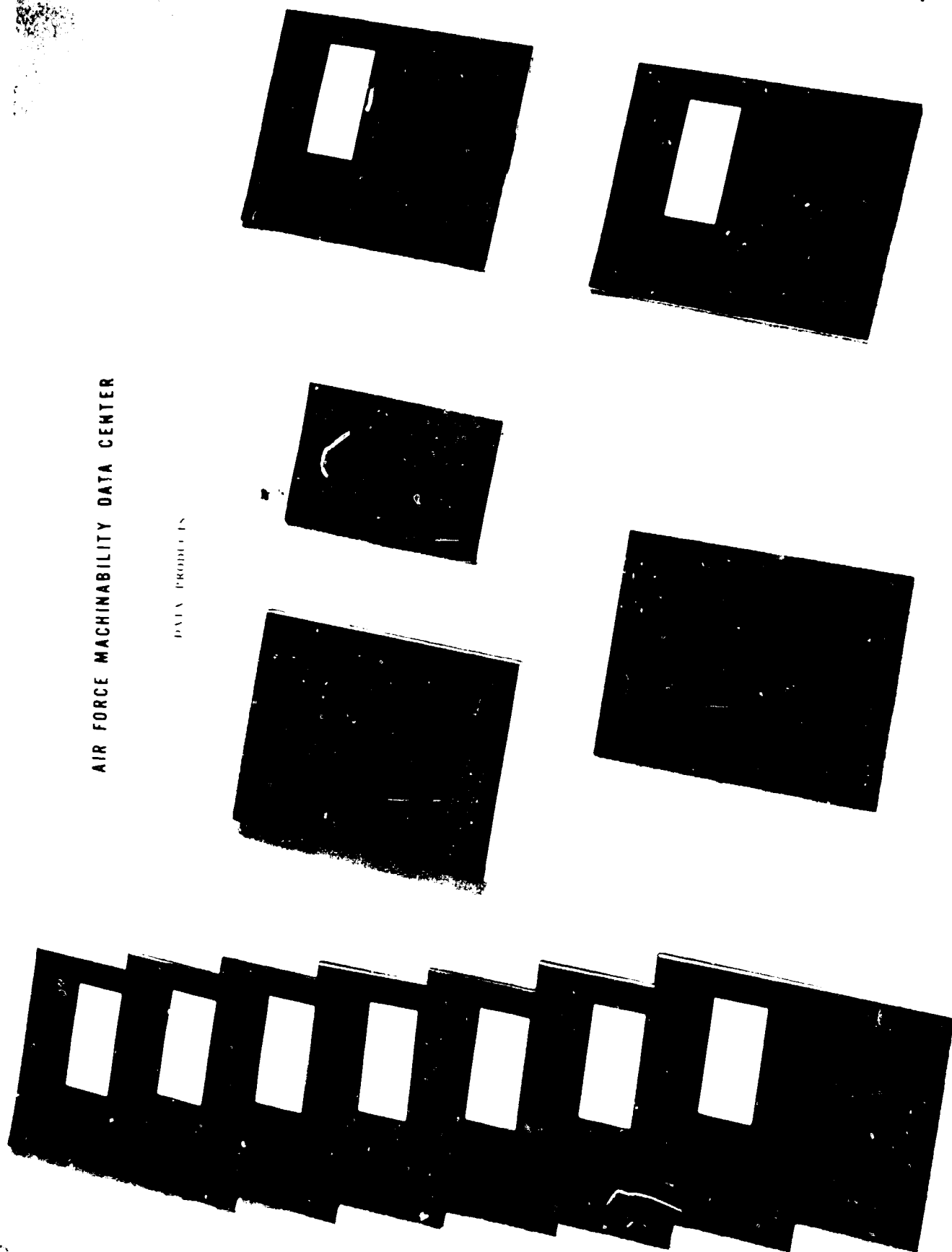
1 February 1966 - 31 January 1967

AEROJET-GENERAL CORPORATION	7	INGERSOLL-RAND COMPANY (3)*	7
AEROSPACE RESEARCH APPLICATIONS CENTER	7	INTERNATIONAL NICKEL CO., INC. (THE) (2)*	10
AVCO CORPORATION (4)*	7	JERDEN MANUFACTURING COMPANY	4
BATTELLE MEMORIAL INSTITUTE	9	LEBLOND TOOL COMPANY, R.K.	4
BENDIX CORPORATION (THE) (2)*	4	LOCKHEED AIRCRAFT CORPORATION (3)*	10
BOEING COMPANY (THE) (4)*	8	MARTIN COMPANY (2)*	8
BRUSH BERYLLIUM COMPANY (THE)	4	METCUT RESEARCH ASSOCIATES INC.	4
BURNDY CORPORATION	4	MCDONNELL AIRCRAFT CORPORATION	8
CHAMBERS AIRCRAFT	4	NATIONAL LEAD CO. OF OHIO (2)*	7
CINCINNATI MILLING MACHINE CO. (THE)	13	NORTH AMERICAN AVIATION, INC. (6)*	23
CINCINNATI SHAPER COMPANY	4	PENNSYLVANIA STATE UNIVERSITY	4
CURTIS-WRIGHT CORPORATION	10	RAYTHEON COMPANY (3)*	4
DOUGLAS AIRCRAFT CO., INC.	7	ROCK ISLAND ARSENAL	5
DUPONT DE NEMOURS & CO., E.I.	5	SUNDSTRAND AVIATION	5
ELLIOTT COMPANY	4	TRW INC.	7
FISCHER GOVERNOR COMPANY	4	THERM INC.	4
GENERAL DYNAMICS CORPORATION (2)*	8	THIokol CHEMICAL CORPORATION	7
GENERAL ELECTRIC COMPANY (17)*	47	TINKER AIR FORCE BASE	4
GENERAL MOTORS CORPORATION (4)*	7	TOOL SALES & SERVICE	5
GOODYEAR AEROSPACE CORPORATION	5	UNION CARBIDE CORPORATION (4)*	8
GRUMMAN AIRCRAFT ENGINEERING CORPORATION	13	WAYNE STATE UNIVERSITY	9
HAMILTON STANDARD	4	WRIGHT-PATTERSON AIR FORCE BASE	11

*() = No. of divisions.

AIR FORCE MACHINABILITY DATA CENTER

DATA PROFILES



SEE APPENDIX, PAGE A.13

FIGURE 13

TYPICAL FORMATS FOR DATA PRESENTATION

TURNING

MATERIAL	CONDITION & MICROSTRUCTURE	TOOL MATERIAL		TOOL GEOMETRY				CUTTING FLUID	DEPTH OF CUT in.	FEED ipf	TOOL LIFE - minutes	
		TRADE NAME	INDUSTRY GRADE	BR °	SR °	SCFA °	ECEA °	RELIEF °			TOOL LIFE END POINT in.	SPEED-feet/minute R-Recommended Speed
HIGH TEMPERATURE ALLOYS - NICKEL BASE Brought - INCONEL 718	SOLUTION TREATED & AGED AUSTENITIC	45 R _c	T 5 HSS	0	15	15	15	5	.032	.007	.060	3 40
		45 R _c	C-2	0	5	15	15	5	.032	.009	.015	10 15 29 123 117 90

PERIPHERAL END MILLING

MATERIAL	CONDITION & MICROSTRUCTURE	TOOL MATL.		NO. TEETH	FLUTE LENGTH in.	UP OR DOWN MILLING	TOOL GEOMETRY				CUTTING FLUID	DEPTH OF CUT in.	WIDTH OF CUT in.	FEED ipf	TOOL LIFE/CUTTER inches work travel vs SPEED-feet/minute R-Recommended Speed	
		TRADE NAME	INDUSTRY GRADE				HELIX ANGLE °	RR °	CHAMFER °	ECEA °					TOOL LIFE END POINT in.	SPEED-feet/minute R-Recommended Speed
HIGH TEMPERATURE ALLOYS - NICKEL BASE Brought - INCONEL 718	SOLUTION TREATED & AGED AUSTENITIC	42 R _c	M2 HSS	4	2	DOWN	30	10	45	1	3	.11	.125	.001	.012	24 11
									.060		7	1:20				

DRILLING

MATERIAL	CONDITION & MICROSTRUCTURE	DRILL MATL.		DRILL SIZE		TYPE POINT	DRILL GEOMETRY			CUTTING FLUID	DEPTH OF HOLE in.	FEED ipf	DRILL LIFE END POINT in.	DRILL LIFE NO. OF HOLES vs SPEED-feet/minute R-Recommended Speed	
		TRADE NAME	INDUSTRY GRADE	DIA. in.	LENGTH in.		HELIX ANGLE °	POINT ANGLE °	LIP RELIEF °					TOOL LIFE END POINT in.	SPEED-feet/minute R-Recommended Speed
HIGH TEMPERATURE ALLOYS - NICKEL BASE Brought - INCONEL 718	SOLUTION TREATED AUSTENITIC	245	T15 HSS	.250	2.5	1.375	CRANK-SHAFT	29	118	7	.5 THRU	.002	.015	21 25	
										53					

DATA ACQUISITION STUDY

These tables were compiled as a result of a document acquisition study conducted by AFMDC to determine the extent of coverage by AFMDC of the machining information published in the English language. A sample period of January to June 1964 was selected as a representative period. Four major services were chosen to study the sources selected by these services and the articles picked from these sources.

COVERAGE FOR SIX MONTH PERIOD

SOURCES

<u>SERVICE</u>	<u>PERIODICAL</u>	<u>NON-PERIODICAL</u>	<u>TOTAL</u>
SERVICE NO. 1	93	48	141
SERVICE NO. 2	93	10	103
SERVICE NO. 3	90	0	90
SERVICE NO. 4	48	0	48
AFMDC	150	450	600

MACHINING ARTICLES

SERVICE NO. 1	324	57	381
SERVICE NO. 2	276	10	288
SERVICE NO. 3	341	19	360
SERVICE NO. 4	247	0	247
AFMDC	1,050	500	1,550

DATA ACQUISITION PLANT VISIT PROGRAM

Twenty plants were visited in late 1966 and January 1967 for the purpose of acquiring machining data from them on a regular basis. Emphasis was placed on visiting aerospace firms. Visits to all plants were very satisfactory and there was general interest in this project. Nearly all the plants are taking steps to make necessary arrangements for transmitting data. Over 100 reports of high data yield have already been received from several firms. Followup is planned in the form of correspondence and periodic visits.

During all visits it was found essential to provide rather detailed information concerning AFMDC's organization and how it functions. Effort was made to reach directly or through responsible supervisory personnel the lower echelon manufacturing and manufacturing engineering people who need data for immediate application to machining of hardware. The effect of this approach was noted in the significant increase in inquiries received from most of the companies visited. The specific companies visited are:

Aerojet-General Corporation
Sacramento, California

The American Welding & Manufacturing Company
Warren, Ohio

Argonne National Laboratories
Argonne, Illinois

Avco Corporation
Nashville, Tennessee

Bell Helicopter Company
Ft. Worth, Texas

The Boeing Company
Seattle, Washington

Douglas Aircraft Company, Inc.
Santa Monica, California

General Dynamics/Convair
San Diego, California

General Dynamics Corporation
Ft. Worth, Texas

Hughes Aircraft Company
Culver City, California

Ling-Temco-Yought, Inc.
Dallas, Texas

Lockheed Aircraft Corporation
Burbank, California

Lockheed-Georgia Company
Marietta, Georgia

Lockheed Missiles & Space Company
Sunnyvale, California

Martin-Marietta Corporation
Orlando, Florida

McDonnell Aircraft Corporation
St. Louis, Missouri

North American Aviation, Inc.
Los Angeles, California

Pratt & Whitney Aircraft
West Palm Beach, Florida

Rocketdyne/North American Aviation, Inc.
Canoga Park, California

Solar/Div. of International Harvester
San Diego, California

CODE SHEET FOR PROJECT TIME CARD

(USED BY EMPLOYEES FOR RECORDING HOURS ON DAILY TIME CARDS)

<u>DIRECT LABOR</u>	1000	<u>DATA ACQUISITION - LITERATURE</u>	1270
<u>INQUIRIES</u>	1100	INDUSTRIAL CONTRIBUTORS OF MACHINING	
ENGINEERING SUPERVISION*	1110	REPORTS AND CASE HISTORIES	1271
INQUIRY STRATEGY AND INQUIRY APPROVAL	1111	DOMESTIC PERIODICAL LITERATURE	1272
<u>MACHINING DATA ANALYSIS</u>	1120	FOREIGN PERIODICAL LITERATURE	1273
ANSWERING INQUIRIES	1121	INDUSTRIAL TRADE LITERATURE	1274
<u>DATA PROCESSING</u>	1130	TECHNICAL INSTITUTIONS, PROFESSIONAL	
KEYPUNCHING	1131	SOCIETIES, AND ASSOCIATIONS	1275
VERIFICATION	1132	PUBLISHERS OF HANDBOOKS, MANUALS, BOOKS	1276
SORTING	1133	INFORMATION CENTERS	1277
CODING	1134	GOVERNMENT AGENCIES	1278
DECODING	1135	MACHINABILITY LABORATORIES	1279
COMPUTER PROCESSING	1136	<u>DATA ACQUISITION - BY TECHNICAL PERSONNEL</u>	1280
<u>DATA CONTROL</u>	1140	PLANT VISITS	1281
FORMS AND DOCUMENT HANDLING	1141	TELEPHONE, TWX, TELEGRAM	1282
<u>DATA ACQUISITION*</u>	1150	LETTERS	1283
SPECIAL ACQUISITION FOR INQUIRIES	1151	TECHNICAL MEETINGS (MACHINABILITY)	1284
<u>REPRODUCTION*</u>	1160	TECHNICAL MEETINGS (INFORMATION SCIENCE)	1285
XEROX	1161	FOREIGN PLANT VISITS	1286
DITTO	1163	FOREIGN TECHNICAL MEETINGS	1287
DRAWING	1165	INDUSTRY SPECIAL	1288
<u>SYSTEMS ANALYSIS</u>	1170	<u>DATA STORAGE</u>	1290
TECHNICAL REVIEW	1171	DOCUMENT FILE	1291
COST EVALUATION	1172	SUPPORT INFORMATION (BOOKS, ETC.)	1292
<u>VISITS TO AFMDC - TECHNICAL*</u>	1180		
MANUFACTURING TECHNOLOGY DIVISION	1181	<u>GENERAL DISSEMINATION OF MACHINABILITY</u>	
OTHERS	1182	<u>DATA AND CENTER INFORMATION</u>	1300
		PUBLICATION IN TECHNICAL LITERATURE	1310
<u>ORIGINAL DATA ENTRY</u>	1200	PRESENTATION AT TECHNICAL MEETINGS	1311
ENGINEERING SUPERVISION	1210	PRESENTATION AT PLANTS	1312
TECHNICAL PLANNING	1211	AFMDC EXHIBITS	1320
<u>MACHINING DATA ANALYSIS</u>	1220	NEWSPAPERS (METALWORKING, ETC.) & MAGAZINES	1330
PRELIMINARY SCREENING	1221	USER LIST (TECHNICAL ASPECTS)	1340
PRELIMINARY TECHNICAL EVALUATION	1222	USER LIST PRODUCTS	1350
FINAL TECHNICAL EVALUATION (put Document		AFMDC PAMPHLETS, ANNOUNCEMENTS, ETC.	1360
Control No. on Daily Time Slip)	1223	SPECIAL REPORTS (STATE-OF-THE-ART, ETC.)	1370
<u>DATA PROCESSING</u>	1230	BIBLIOGRAPHIES	1380
KEYPUNCHING	1231		
VERIFICATION	1232	<u>AFMDC SYSTEM REPORTS AND MEETINGS</u>	1400
SORTING	1233	MONTHLY (MTD)	1410
CODING	1234	QUARTERLY (MTD)	1420
DECODING	1235	ANNUAL (MTD)	1430
COMPUTER PROCESSING	1236	OPERATIONS MANUAL	1440
<u>DATA CONTROL</u>	1240	DETAILED CODE BOOK	1450
FORMS AND DOCUMENT HANDLING	1241	AFMDC MEETINGS	1460
<u>REPRODUCTION</u>	1250	MANUFACTURING TECHNOLOGY DIVISION AND	
XEROX	1251	INFORMATION BRANCH MEETINGS, REPORTS,	
DRAWING OF DATA SHEETS, ETC.	1253	AND CONFERENCES	1470
<u>SYSTEMS ANALYSIS</u>	1260	SPECIAL REPORTS FOR MANUFACTURING TECHNOLOGY	
TECHNICAL REVIEW	1261	DIVISION, DOD, ETC.	1480
COST EVALUATION	1262		
DATA ACQUISITION EVALUATION	1263	<u>MACHINING DATA VERIFICATION - EXPERIMENTAL</u>	1500
		(PROVISIONAL - PRESENTLY INACTIVE)	
		PLANNING	1501
		TESTING	1502
		REPORTS	1503

*Put Inquirer and Sequence numbers in Operation space on Time Card. The Inquirer No. and Sequence No. are those blocked out at the top of IF-1 as shown here:

CODE SHEET FOR PROJECT TIME CARD (continued)

<u>SYSTEMS ANALYSIS - GENERAL</u>	1600
1130 COMPUTING SYSTEM (SYSTEMS ASPECTS)	1610
STATISTICAL PROGRAM FOR ANALYSIS OF CENTER EFFECTIVENESS (SPACE)	1620
1130 COMPUTING SYSTEM (TECHNICAL ASPECTS)	1630
 <u>INDIRECT LABOR</u>	 0000
GENERAL REPAIR, CLEANING, PAINTING	0101
TRAINING	0102
SICKNESS OR EXCUSED ABSENCE	0103
VACATION	0104
ACQUISITION OF MAJOR FACILITIES AND EQUIPMENT	0105
ACQUISITION OF MINOR EQUIPMENT AND SUPPLIES	0106
PROPOSALS AND SETTING UP PROGRAMS	0116
TECHNICAL MEETINGS AND PAPERS (NOT DIRECTLY RELATED TO AFMDC)	0127
GENERAL AFMDC CLERICAL AND OFFICE WORK	0128
GENERAL AFMDC ADMINISTRATION	0150
TYPING AND CLERICAL ON INQUIRIES	0151
TYPING AND CLERICAL ON ORIGINAL DATA ENTRIES	0152
HANDLING OF MAIL	0153
PERSONNEL (HIRING, ETC.)	0154
USER FILE (TYPING AND CLERICAL)	0155
VISITORS (TRANSPORTATION, SYSTEM DEMONSTRATION, GENERAL AFMDC INFORMATION)	0156
DATA PROCESSING (TIME CARDS, ETC.)	0157
TYPING AND CLERICAL ON USER PRODUCTS	0158
MISCELLANEOUS AFMDC NONCHARGEABLE SERVICES	0159
LIBRARY-SUPPORT INFORMATION	0160

<u>PURCHASES</u>	800
FOR PURCHASES PRECEDE CODE BY:	
<u>Examples.</u>	
800-1230 IBM CARDS FOR DATA PROCESSING, ETC.	
800-0000 INDIRECT CHARGES SUCH AS GENERAL SUPPLIES	
800-1272 PURCHASE OF DOMESTIC PERIODICAL LITERATURE	

AFMDC OPERATING COSTS

FEBRUARY 1, 1966 - JANUARY 31, 1967

INPUT COSTS	
TECHNICAL EVALUATION	\$ 36,974.20
DATA PROCESSING	26,709.69
DOCUMENT ACQUISITION & REPRODUCTION	22,224.11
	85,908.00
EQUIPMENT, SUPPLIES & SERVICES	13,789.76
TOTAL	\$ 99,697.76
OUTPUT COSTS	
INQUIRIES:	
TECHNICAL EVALUATION	\$ 25,228.19
DATA PROCESSING & RETRIEVAL	5,029.59
DATA ACQUISITION & REPRODUCTION	1,934.68
	32,192.46
GENERAL DISSEMINATION OF MACHINABILITY DATA & CENTER INFORMATION	7,235.21
USER LIST PRODUCTS:	
MACHINING DATA FOR NUMERICAL CONTROL (7 individual reports, Nos. AFMDC 66-1.1 thru AFMDC 66-1.7 covering Turning, Face Milling, Drilling, Peripheral End Milling, End Mill Slotting, Tapping and Reaming respectively).	
MACHINING DATA FOR NUMERICAL CONTROL, AFMDC 66-1 (composite of above mentioned 7 reports).	23,143.57
GRINDING RATIOS FOR AEROSPACE ALLOYS, AFMDC 66-2	
MACHINING DATA FOR BERYLLIUM METAL, AFMDC 66-3	
PRINTING COSTS	5,396.82
DATA PRODUCTS IN PROCESS	3,255.60
AFMDC SYSTEMS REPORTS	3,388.57
PRINTING COSTS	469.25
AFMDC, MTD & INFORMATION BRANCH MEETINGS & SPECIAL MTD REPORTS	5,561.02
	80,642.50
EQUIPMENT, SUPPLIES & SERVICES	7,512.20
TOTAL	\$ 88,154.79
SYSTEMS ANALYSIS, MODIFICATION & CONTROL	
TECHNICAL EVALUATION	\$ 1,882.28
DATA PROCESSING - IBM 1130 COMPUTING SYSTEM:	
TECHNICAL ASPECTS	9,319.18
SYSTEMS ASPECTS	7,901.46
DATA ACQUISITION	5,160.21
OPERATIONS MANUAL & CODE BOOK REVISIONS & ADDITIONS	1,487.31
	25,749.44
EQUIPMENT, SUPPLIES & SERVICES	3,480.96
TOTAL	\$ 29,230.40
TOTAL ACTUAL COSTS NOT INCLUDING FIXED FEE	\$ 217,082.86

AFMDC INPUT AND OUTPUT SUMMARY

FEBRUARY 1, 1966 - JANUARY 31, 1967

SYSTEM INPUT

Document and Card Totals

Documents Entered into the System (including Evaluated Inquiries)	8,860
Evaluated Documents:	
Final Technical Evaluation Completed	1,350
Preliminary Technical Evaluation Completed	6,996
Inquiries Entered as Documents with Evaluation Completed	<u>736</u>
	9,082
Machining Situations Evaluated and Ready for Coding	23,725
Machining Situations in Storage	46,428
Cards Punched	58,241

Unit Costs

Per Machining Situation (Data Points) Evaluated & in Storage (46,428)	\$ 2.15
Per Card Punched (58,241)	\$ 1.71

SYSTEM OUTPUT

Specific Inquiries

Inquiries Received	736
Individual Companies Represented	396
U.S. Government Standard Industrial Classification (SIC) Represented	90

Data Products

Total Copies Distributed:	13,706
AFMDC 65-1, Machining Data for Titanium Alloys	4,376
AFMDC 66-1, Machining Data for Numerical Control	207
AFMDC 66-1.1, Machining Data for Numerical Control-Turning	1,162
AFMDC 66-1.2, Machining Data for Numerical Control-Face Milling	1,097
AFMDC 66-1.3, Machining Data for Numerical Control-Drilling	1,083
AFMDC 66-1.4, Machining Data for Numerical Control-Peripheral End Milling	1,067
AFMDC 66-1.5, Machining Data for Numerical Control-End Mill Slotting	1,065
AFMDC 66-1.6, Machining Data for Numerical Control-Tapping	1,060
AFMDC 66-1.7, Machining Data for Numerical Control-Reaming	1,060
AFMDC 66-2, Grinding Ratios for Aerospace Alloys	728
AFMDC 66-3, Machining Data for Beryllium Metal	801

Unit Costs

Per Inquiry (736)	\$45.02
Per Data Product (including cost of preparation & printing, per copy)	
AFMDC 65-1, Machining Data for Titanium Alloys	\$ 1.04
AFMDC 66-1, Machining Data for Numerical Control	\$ 6.34
AFMDC 66-1.1, Machining Data for Numerical Control-Turning	\$ 4.07
AFMDC 66-1.2, Machining Data for Numerical Control-Face Milling	\$ 3.66
AFMDC 66-1.3, Machining Data for Numerical Control-Drilling	\$ 3.65
AFMDC 66-1.4, Machining Data for Numerical Control-Peripheral End Milling	\$ 1.11
AFMDC 66-1.5, Machining Data for Numerical Control-End Mill Slotting	\$ 1.58
AFMDC 66-1.6, Machining Data for Numerical Control-Tapping	\$ 1.24
AFMDC 66-1.7, Machining Data for Numerical Control-Reaming	\$ 0.85
AFMDC 66-2, Grinding Ratios for Aerospace Alloys	\$ 3.50
AFMDC 66-3, Machining Data for Beryllium Metal	\$ 5.98

AFMDC DATA PRODUCTS

DESCRIPTION & CONTENT	DISTRIBUTION			COST
	USER FILE & DIRECT INQUIRIES	NO. SOLD	TOTAL	
AFMDC 65-1.1, MACHINING DATA FOR TITANIUM ALLOYS. AUGUST 1965 TURNING, FACE MILLING, END MILL SLOTTING, PERIPHERAL END MILLING, DRILLING, REAMING, TAPPING, BROACHING AND SURFACE GRINDING FOR COMMERCIALLY PURE TITANIUM, ALPHA & ALPHA-BETA, AND BETA ALLOYS.	2,255	1,121	4,376	\$ 5,838.05
AFMDC 66-1.1, MACHINING DATA FOR NUMERICAL CONTROL, DECEMBER 1966 CONTAINS ALL THE DATA ORIGINALLY PRINTED IN THE 7 INDIVIDUAL REPORTS, AFMDC 66-1.1 THROUGH 66-1.7 LISTED BELOW. (See Notes).	67	140	207	3,169.87
AFMDC 66-1.1.1, MACHINING DATA FOR NUMERICAL CONTROL-TURNING, JUNE 1966 FREE MACHINING PLAIN CARBON STEELS, PLAIN CARBON STEELS, FREE MACHINING ALLOY STEELS, ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACTORY ALLOYS, AND NONMETALLICS.	1,082	80	1,162	4,777.95
AFMDC 66-1.2, MACHINING DATA FOR NUMERICAL CONTROL-FACE MILLING, AUGUST 1966 ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACTORY ALLOYS, AND NONMETALLICS.	1,071	26	1,097	4,026.92
AFMDC 66-1.3, MACHINING DATA FOR NUMERICAL CONTROL-DRILLING, AUGUST 1966 ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACTORY ALLOYS, AND NONMETALLICS.	1,070	13	1,083	4,016.66
AFMDC 66-1.4, MACHINING DATA FOR NUMERICAL CONTROL-PERIPHERAL END MILLING, SEPTEMBER 1966 ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, AND REFRACTORY ALLOYS.	1,065	2	1,067	1,223.43
AFMDC 66-1.5, MACHINING DATA FOR NUMERICAL CONTROL-END MILL SLOTTING, SEPTEMBER 1966 ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, AND REFRACTORY ALLOYS.	1,063	2	1,065	1,733.11
AFMDC 66-1.6, MACHINING DATA FOR NUMERICAL CONTROL-TAPPING, NOVEMBER 1966 ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS-HOT WORK, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACTORY ALLOYS, AND NONMETALLICS.	1,060	-	1,060	1,364.97
AFMDC 66-1.7, MACHINING DATA FOR NUMERICAL CONTROL-REAMING, NOVEMBER 1966 ULTRA-HIGH STRENGTH STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, AND REFRACTORY ALLOYS.	1,060	-	1,060	934.84
AFMDC 66-2, GRINDING RATIOS FOR AEROSPACE ALLOYS, JUNE 1966 SURFACE GRINDING OF ALLOY STEELS, ULTRA-HIGH STRENGTH STEELS, TOOL STEELS, STAINLESS STEELS, TITANIUM ALLOYS, HIGH TEMPERATURE ALLOYS, REFRACTORY ALLOYS AND NONMETALLICS.	670	58	728	2,621.32
AFMDC 66-3, MACHINING DATA FOR BERYLLIUM METAL, JUNE 1966 THIS BOOKLET COVERS PROBLEMS INVOLVED IN MACHINING BERYLLIUM, IN ADDITION TO SPECIFIC DATA FOR 10 CONVENTIONAL OPERATIONS AND 4 ALTERNATE MACHINING METHODS.	687	114	801	5,084.82
TOTALS	12,150	1,556	13,706	\$34,791.94

*Printing Costs include copies still available at AFMDC.

FUTURE PLANNING

MAJOR GOALS FOR 1967:

1. Increase utilization of User File to meet needs of manufacturing engineers and to increase personal contact with the users of the data.
2. Provide users with a list of the materials, operations and keywords used by the Data Center to index documents.
3. Initiate a program by which inquirers who submit specific inquiries may be kept up-to-date on a monthly basis.
4. Continue setting up the statistical program to analyze Center activities in order to better determine input and output needs.
5. Continue the program of plant visitation to make industry aware of the data stored by AFMDC and to obtain cooperation on input to AFMDC.
6. Prepare several data products including the following three which are in preparation:
 - a) Machine Tool Requirements, Average Unit Power and Surface Finish Data for Aerospace Materials.
 - b) Tool Geometry Nomenclature and Recommendations.
 - c) Formulas and Computer Programs for Calculating Machining Costs and Production Rates.

APPENDIX

Description of AFMDC (page 1)

This description of AFMDC is distributed by the Center in the form of a pink flyer (3-1/2" x 7-1/2") with the information relating to Scope, Collection, and Information Services on one side of the card and with instructions on how to request machining information from AFMDC on the other side. The pink flyer is convenient in size which makes it possible to include it in all types of mailings and to use it for handouts at meetings and for Center visitors. Various plants have also used AFMDC flyers to acquaint machining personnel with Center services.

By including detailed information on how to request machining information, it is hoped that some loss in time can be avoided and that the search strategy required will be simplified. Information shown on page 1 has also been furnished for the Air Force Materials Information Centers (AFMIC) booklet, November 1965, and for the revision now being processed.

AFMDC Organization Chart (Figure 1, page 2)

This Organization Chart is self-explanatory, but certain comments may be helpful toward gaining a fuller understanding of the basic plan. One of the most important aspects of AFMDC's organization relates to use of Machining Data Analysts. These Analysts are professionally trained, experienced people who have the capability of judging the value of machining information for input purposes and to make technical analyses of output used for answering specific inquiries as well as developing data products.

Systems Analysts are employed on a part-time basis, with emphasis being placed in three areas: 1) Data Processing, 2) Document Processing, and 3) Data Acquisition. Consultants are used to a limited extent.

Up to the present time, almost complete emphasis has been given to domestic considerations. Since the foreign literature and foreign efforts relating to machinability are significant, this area has been covered by using a consultant to report on foreign trends as they may influence need for domestic cognizance.

The Organization Chart indicates requirements for employing one additional Machining Data Analyst. Since AFMDC is operated by Metcut Research Associates Inc., full advantage is taken of the capabilities of Metcut personnel not associated with AFMDC on a full-time basis. This includes Dr. Michael Field, president of Metcut, Mr. Norman Zlatin, vice-president of Metcut, and Mr. John Christopher, who is a project engineer in charge of experimental machining data being developed at Metcut.

Since metal removal is a very complex technical discipline, it is obvious that not all of the capability required can be centered in one organization, and therefore use has been made of part-time analysts located at several companies.

Two important areas of AFMDC systems are document acquisition and data processing. Document acquisition is responsible for acquiring input from both domestic and foreign sources covering the entire broad scope of machining information required to meet the output of the Center. Data processing is a key function required for storage and retrieval of the detailed evaluated and coded information extracted by Machining Data Analysts. Mechanical processing of data was accomplished prior to July 1, 1966 by Electrical Accounting Machine (EAM) equipment. This equipment now supports the IBM 1130 computer, which is the medium for storage and retrieval of processed information.

From an information point of view, the Organization Chart also reflects handling aspects of information which do not require full-time activity. Trained competent secretarial personnel handle activities such as supervision of the User and Inquiry Files and supervision of production of data products.

Part-time Systems Analysts are used to develop required computer programs and systems evaluation of current operations. Capability of full-time engineering and data processing personnel is being developed to supplement the effort now being expended by part-time Systems Analysts.

AFMDC Operational Areas (page 3)

Each of the functional areas of operation of AFMDC has been assigned a code number from 1 through 9 and 0. These time codes are used in connection with the codes for the project time card in Figure 23, pp 34 and 35. For example, a Machining Data Analyst in functional area No. 4 who is answering inquiries will use the code 4-1121. If a Machining Data Analyst in area No. 4 is performing in another operational area, such as assisting in technical aspects of document acquisition by obtaining data from industrial plants (see Figure 23, time code 1281), he will use the time code 7-1281. Since the project time card also includes his employee number and the operational area in which he functions, it is possible to determine the extent of time spent by employees in their principal assigned area as compared with time they spend in other functional areas of the Center (see actual Daily Time Slip on page A-16. More important, the stored punched card information from the project time card is valuable in providing detailed analyses of the various cost aspects pertaining to the Center's operation.

AFMDC Operations Chart (Figure 2, page 4)

Basically the Operations Chart divides functions into two principal parts: 1) System Input, and 2) System Output. The other function shown in the heading is System Analysis and is linked to input and output to insure and measure the effectiveness of the two major functions. All sources of information are referenced as 'documents' regardless of whether they are journals, meeting notes, microfilm, magnetic tape, phonograph records, etc.

System Input consists of the steps shown in Figure 2 which are designed to accept any type of document from any source and process it so that each document becomes an entity within the system. The steps are set so that documents may be evaluated as to the nature of the information contained in view of the computer programs and codes which were established and are modified by System Analysis. If the documents are deemed to be valuable to AFMDC in Preliminary Screening, they are sent on to Preliminary Technical Evaluation. This step determines whether or not the document contains sufficient numerical data to warrant extraction of this data so that the data may be punched into cards. If the document does contain data to be extracted, it is sent on to Final Technical Evaluation; if not, the document is Final Evaluated at this step. Documents without a significant amount of numerical data are described to the system by listing the machining operation, material group, material description, material hardness, and tool material which is punched into an index card for that document. At this step, all documents are assigned uniterms where applicable to describe the text to the system. These uniterms, together with the source control number, are punched into card formats. Examples of printouts of these may be found in Figure 8, page 12.

Some of the documents contain sufficient information to warrant creation of a file containing the numerical data and tool geometry for each machining situation. The documents which are so evaluated in the previous step now have the data extracted and placed on the forms shown in Figure 5, page 9. These forms are given to a keypunch operator who punches cards which will be stored on the computer. A printout of this type of information is shown in Figure 9, page 13.

System output consists of the three basic types of output: 1) specific inquiries, 2) data products, and 3) general dissemination. Specific inquiries may be submitted to AFMDC by anyone qualified as a User of AFMDC. The request may be in the form of specific data for a machining situation or series of machining operations, state-of-the-art studies, etc. A list of the types of inquiries is shown in Figure 15, page 19.

Data products are published by AFMDC on timely subjects which are comprehensive studies and generally take the form of charts of data for one or more alloys. The charts contain all the known data for machining parameters,

tool geometry, coolant, tool material and other considerations directly applicable to the machining situation. When data products become available a notice is sent to every individual on the User File. Through this notice the User can select information applicable to his needs.

General dissemination takes the form of plant visits for coordination (see page 33), writing technical papers for presentation at meetings or presentation in the literature. AFMDC is always open to visitors and technical personnel are available to discuss various problems in detail and to show the User how AFMDC can assist his operation.

AFMDC User File Map (Figure 3, page 5)

The User File map shows the number of companies per state and the total number of individual Users in those companies per state. These figures do not include Universities, Colleges, other Centers, Publishers or Societies. Six states have no Users and many states have less than five companies. Hawaii has only College Users. As would be expected, the heavy concentration of Users is in heavy industrial sections and the West Coast aerospace industry.

Distribution of AFMDC User File (page 6)

The basic User File was developed by using the following sources:

World Space Directory, Volume 3, No. 1 - This directory contains a large index of plants associated with the aerospace industry. An important section lists the "Major Missile and Space Manufacturers". Request forms were sent to key people in all of the company listings in this section, and provision was made in the form allowing for listing additional personnel, personnel from other divisions, and major subcontractors.

Manufacturing Committee of the Aerospace Industries Association, Washington, D.C. - This is an important aerospace group which has need for machining information in the solution of their common industry problems.

The American Society for Engineering Education (including members of the Engineering College Administrative Council, Engineering College Research Council, Technical Institute Council and Industrial Members) - Letters were sent to the deans of all of the important colleges which have significant interest in machining through departments such as: Aeronautical Engineering; Ceramic Engineering; General Engineering; Industrial Engineering; Mechanical Engineering; Metallurgical Engineering; Pre-Engineering; Engineering Extension Groups; Control, Computer and Information Science Departments;

Material and Engineering Sciences; and Technical Engineering Institutes and Engineering Research Groups oriented in disciplines of materials and material removal. Products of the Center have been helpful to college students, some of whom are already engaged in time standards work, manufacturing engineering, etc., in cooperative work programs and in summer jobs. Even more important is the fact that the training of engineers and thus their future professional performance will be influenced through AFMDC's activities.

Information Sources - Listings were compiled from "A Directory of Information Resources in the United States", National Referral Center for Science and Technology, Library of Congress, January 1965. The prime function of the Referral Center is to direct people to the proper information sources, including Centers, in the United States. Their directory contains a large listing of Centers, Technical Societies, Government agencies, etc., which in turn disseminate information to their various clientele. This directory was reviewed and selections for the User File were made.

1964 "ASM Index for the Review of Metal Literature" - This list includes societies and trade publications in the United States, and from it selections were made of those concerned with material removal.

Manufacturing Technology Division, Wright-Patterson AFB, Ohio, Report Distribution Lists - It should be noted that these distribution lists include other Departments of the Air Force, the Departments of the Army, Navy, Defense, and other Government agencies.

Inquirers - People who request information from AFMDC are termed 'inquirers'. Most new inquirers not already listed in the User File are added to it. Since there have been 1,331 inquiries during the two years operation of AFMDC, it is quite obvious that the file will grow considerably from this source alone.

Materials Advisory Board (MAB) Committee on Manufacturing Requirements for Aerospace Materials and the Ad Hoc Committee on Aerospace Manufacturing Requirements - This group was contacted because of its importance in manufacturing planning at a national level.

The methods stated in page 6 are used to continue adding names to the User File. The present total is 3,574 Users.

Welcome to AFMDC Visitor (page 7)

The printout shown on page 7 was run on the IBM 1130 computer system which is the data storage and retrieval mechanism for the Air Force Machinability Data Center. Each visitor to AFMDC is requested to fill in a Registration Card which is used to prepare a printout. The visitor receives the printout with his name, title and company at the top, and

the AFMDC host's name and title at the bottom. AFMDC hosts are engineering personnel who discuss with the visitor his machining interests, and also review the operation of the Center. The visitor's experience with respect to types of operations and materials machined is ascertained and this information is then processed for purposes of identifying him as a Potential Source of Information. If the visitor has a specific inquiry, it is processed during his visit, if time allows, or forwarded to him upon completion.

Computer Input and Output Flow Chart (Figure 4, page 8)

The flow pattern described in this diagram gives a picture of the final goals of AFMDC. The procedure for accomplishing this has been set and pilot runs have been made on final output, as will be seen in Figure 9, page 13. All documents with detailed data are given to a Machining Data Analyst so that this data may be extracted and placed in "Data Code Forms", see Figure 5, page 9. This information is then punched on cards from which the disk files are generated. The output of these files, as a result of an inquiry, can then be mailed to the User.

Data Code Forms for Final Technical Evaluation (Figure 5, page 9)

Figure 5 is a photograph showing both the front and back of Data Code Forms used as an intermediate step between the original document and the punched cards used as input to disk storage. The formats are designed to handle alphameric information required for some parameters and decimal numbers for others, as well as integers. These formats and a book with codes enable the Machining Data Analyst to concisely identify the important information regarding a specific machining situation. Required decimals are set in the numerical data fields, thereby further simplifying recording of the data. These forms are then passed to the keypunch operator, who punches the information contained in them into Index, Tool Geometry, and Numerical Data Cards.

These, plus the additional cards used by AFMDC are described as follows:

<u>Card</u>	<u>Description</u>
0 Inquiry	The Inquiry Card is punched with the inquiry information desired and is used by matching key indices in exactly the same columns as information which would have been precoded into the System.
1 Index	The Index Card establishes information available in the System by preassigned data index columns and respective codes to be matched against

Card	Description
1 Index (cont.)	inquiries. The Index Card describes the machining situation including the machining operation, specific material designation, hardness, condition, heat treatment, and broad material group. In addition to the above "minimum requirements", the Index Card also includes the part configuration code, tool material, machine tool description, and the control codes. The control codes provide information on the data source, its classification and index controls which allow for retrieval monitoring. The primary method of access into the AFMDC information decks is through the Index Card.
2 Tool - Cutting Fluid	This card defines tool size, shape, and geometry, as well as the trade name and manufacturer. It also identifies the trade name of the cutting fluid, the manufacturer, and the concentration of the cutting fluid.
3 Numerical Data	The Numerical Data Card contains actual values of machining variables, such as feeds, speeds, depth of cut, hole size, tool life, etc.
4 Uniterm	This card alphabetically describes special technical significance of a document not covered by categories included on the Index, Numerical Data, and Tool-Cutting Fluid Cards.
5 Data Link	This card provides means for eliminating the recording of data relevant to different topics or sources. Data are encoded and stored under one control code.
6 Aperture	The Aperture Card is used to store and retrieve microfilms of pertinent curves, drawings or any information best stored in graphic manner.
7 Bibliography	The Bibliography Card set is designed to present the Source Document in a formalized, uncoded manner.
8 Potential Source of Information	This card records into the System information on contracts awarded and other work initiated or in progress which are considered potential information sources. In this manner, the card helps direct an active data acquisition program. It also serves as a card to store certain bibliographic information such as author and organization.

<u>Card</u>	<u>Description</u>
8 Visitor	This card has the same format as the Potential Source of Information Card and therefore serves not only to develop a Visitor File but can and is used to identify visitors as inquirers and/or potential sources of information.
9 Tickler	The Tickler Card is generated at the time machining information is committed to the System primarily as a review device for updating, purging, etc., but also for checking on commitments for potential sources of information. Dates for tickler review of data committed to the System are based upon the times related and shown in the Classification Code.

Flow Chart for Fortran Program to Store, Add or Search
Inquiry File (Figure 6, page 10)

The flow chart of the inquiry program is an example of the storage and search techniques used by AFMDC on the IBM 1130 computer system. These programs have two basic sections: 1) to create files into which data may be stored, added to and deleted from, and 2) to set up a procedure for searching the data files. Discussion of the inquiry program follows:

- 1) Create data file and store additional cards to file. Console Data Switch No. 0 controls loading of a new deck of cards to create an original file. This file is created in a file protected disk area called "User Area". At the end of each month, inquiries for that month are coded and cards punched. The additional cards are then loaded at the end of the file. Console Data Switch No. 1 is used to control this function of the program. By this procedure, the inquiry file is only one month behind any inquiry ever submitted to AFMDC.
- 2) Search Routine - Since the load and add functions of the program are to be bypassed, Data Switch No. 0 and Data Switch No. 1 are turned off. Control of the parameters to be matched in the search are then selected through the use of Data Switches No. 2, No. 3, No. 4 and No. 5. All or any combination may be selected by the operator as specified by the Machining Data Analyst. These Data Switches (D.S.) control matches for: Specific Machining Operation (D.S. 2); Specific Material Group (D.S. 3); Specific Material Description (D.S. 4); and Uniterm (D.S. 5). Through the use of the Data Switches the computer may be used to narrow the selection of documents if the initial search output yields too many references. This concept is fundamental to all of the search programs operated by AFMDC.

<u>Card</u>	<u>Description</u>
8 Visitor	This card has the same format as the Potential Source of Information Card and therefore serves not only to develop a Visitor File but can and is used to identify visitors as inquirers and/or potential sources of information.
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The flow chart of the inquiry program is an example of the storage and search techniques used by AFMDC on the IBM 1130 computer system. These programs have two basic sections: 1) to create files into which data may be stored, added to and deleted from, and 2) to set up a procedure for searching the data files. Discussion of the inquiry program follows:

- 1) Create data file and store additional cards to file. Console Data Switch No. 0 controls loading of a new deck of cards to create an original file. This file is created in a file protected disk area called "User Area". At the end of each month, inquiries for that month are coded and cards punched. The additional cards are then loaded at the end of the file. Console Data Switch No. 1 is used to control this function of the program. By this procedure, the inquiry file is only one month behind any inquiry ever submitted to AFMDC.
- 2) Search Routine - Since the load and add functions of the program are to be bypassed, Data Switch No. 0 and Data Switch No. 1 are turned off. Control of the parameters to be matched in the search are then selected through the use of Data Switches No. 2, No. 3, No. 4 and No. 5. All or any combination may be selected by the operator as specified by the Machining Data Analyst. These Data Switches (D.S.) control matches for: Specific Machining Operation (D.S. 2); Specific Material Group (D.S. 3); Specific Material Description (D.S. 4); and Uniterm (D.S. 5). Through the use of the Data Switches the computer may be used to narrow the selection of documents if the initial search output yields too many references. This concept is fundamental to all of the search programs operated by AFMDC.

Inquiry File Search (Figure 7, page 11)

The inquiry file which, as of January 31, 1967, contained data pertaining to 1,331 inquiries is a very important AFMDC file. Search of this file can prevent duplicate effort in answering identical inquiries or provide assistance in answering those having similarity.

Figure 7 shows the use of Data Switches described in Figure 6, page 10 as they were utilized to make broad and then selective searches on the inquiry file. The first search was made on the uniterm, CUT FLUID, by having Data Switch No. 5 in the 'on' position. When the file was interrogated the machine selected and printed all inquiries for which the uniterm, CUT FLUID, was used. To be more selective on the second search, material group 301 and material description Inco 718 was added to the CUT FLUID uniterm on the search card. In the third search, the operation requirement was added so that now the search was concentrated on a specific operation, on a specific material group, one material description and a uniterm requirement. From this type of search, the computer finds a precise match and prints that information. The number on the right is a unique number to that inquiry so the information may be reached quite rapidly.

Output of Preliminary Technical Evaluated Data and Uniterm (Figure 8, page 12)

Figure 8 shows a printout of specific searches on the Preliminary Index file and the Uniterm file.

The Preliminary Index file contains six possible terms which can be searched in any combination. Preliminary Technical Evaluation is designed to identify, if available, 1) machining operation, 2) material hardness, 3) material condition, 4) heat treatment, 5) material group, 6) material description, and 7) tool material. With the exception of material condition, an engineer may set up a search strategy to interrogate the file or any combination of the other six parameters. When a match is found, the source control code will be printed and the document pulled from the file. The Preliminary Index search shown in Figure 8 was made on operation and material group.

The uniterm concept was designed so that technical text important to material removal operations could be stored and retrieved. Each document is assigned uniterms (keywords) which describe the nature of the text. These uniterms are punched into cards which are stored on disks.

A master list of the uniterms is contained in the code book so that search strategies may be setup. A search can be made only on a single term at one time. This term may be in any position within the card set. When a match is made, all the uniterms in the card together with the source control code are printed out. The search shown in Figure 8 is for SURF INTEGRITY.

Output of Final Technical Evaluated Data
(Figure 9, page 13)

Figure 9 is the computer printout of decoded information which has been extracted from a document which received Final Technical Evaluation. Note that the information extracted by the Machining Data Analyst and coded on the forms in Figure 5, page 9, is now computer decoded and printed out. The first line of data describes the inquiry to the file. The second line is the AFMDC match on the inquiry search terms; this may be broad or narrow depending on the search strategy set up by the Machining Data Analyst. One requirement is that the operation be specified and identical on the inquiry and index cards because it serves as the instruction to the computer to retrieve the numerical data and tool geometry headings applicable to that operation.

The headings are printed and the retrieved information in the data cell is printed in the proper location. Coded integers are matched against another file on the disk resulting in the alphameric equal being printed on the output sheet. It is anticipated that this type of printout will be used to answer some inquiries directly later this year.

Cost and Production Rate for Turning (Figure 10, page 14)

The use of data shown in Figure 10 leaves something to be desired for the manufacturing engineer. The printout gives a series of values to choose from but does not clearly indicate the economics involved. Since the major reason for having adequate data is to help to minimize the cost, the logical question is which set of values will yield the minimum cost. A basic equation has been developed which considers the economics of each significant element of a machining operation and determines the production cost and production rate. The output gives the cost and production rate and the elements which go into the total cost. These values give the engineer an opportunity to analyze the elements so that he may decide where the major contributors to the total cost lie and then work on the critical areas. Equations will be written for the major conventional chip removal operations, computer programs will be developed, and the entire cost and production rate program will be published as a data product late in 1967.

Inquiry Processing Flow Chart (Figure 11, page 15)
and
Typical Inquiry Input and Response (Figure 12, page 16)

Responses to inquiries are the most important of the services provided by AFMDC. Strong emphasis is placed on providing specific and detailed answers to technical inquiries which are transmitted by letter, telegram, telephone or by direct visitation to the Center. A high percentage of the

inquiries is made via telephone, some because of the urgency of information requirements and others due to the necessity of discussing technical details with the Machining Data Analysts. When required, inquirers are contacted to clarify their specific needs. As indicated in Figure 11, page 15, engineering personnel impose judgments on the inquiries and establish the search strategies. Data Processing personnel perform the computer search functions and provide the printouts to the Machining Data Analysts. The Machining Data Analysts again impose engineering judgment in the selection and preparation of the information to be transmitted to the inquirer.

An inquiry form and the AFMDC response are shown in Figure 12, page 16. Note the codes within the blocks on the form which are keypunched and then stored on the computer inquiry file.

Analysis of Specific Inquiries by Material Group (Figure 13, page 17)

The breakdown shown in Figure 13 of the number of requests made for machining information on various material groups provides AFMDC with perspective of User needs and input requirements. Of the total of 846 requests, 491 were made for high temperature alloys, titanium alloys and refractory alloys. The 38 requests for machining information on nonmetallics are a significant total and there is an increasing interest in these materials. The broad spectrum of the specific inquiries is indicated by the total of 590 machining operations involved in these inquiries.

The 'Analysis of Comprehensive and Uniterm Type Inquiries' section of Figure 13 covers a separate breakdown for inquiries in these categories, of which a total of 1,002 have been processed by AFMDC. A typical example of a comprehensive inquiry is, "We need recommendations for turning, end milling, drilling and tapping of nickel base high temperature alloys and titanium alloys". A uniterm type inquiry is, "Please provide information on the effect of grinding conditions on residual stress and the effect of residual stresses on fatigue life of metals".

Analysis of Inquiries by Type of Machining Operation (Figure 14, page 18)

Added perspective of User needs and in turn AFMDC input requirements is obtained by analyses such as shown in Figure 14. For conventional chip removal types of operations the statistics indicate that emphasis on input and detailed evaluation should be on turning, face milling, end milling, drilling, reaming and tapping. For conventional grinding highest interest is shown in surface, cylindrical and internal grinding operations. Of the alternate machining methods, the preponderance of inquiries was concerned

with electrical discharge machining, electrochemical machining and electrochemical grinding.

Summary of Specific Inquiries by Type of Inquiry
(Figure 15, page 19)

The specific inquiry types listed in Figure 15 provide information on the varied services available at AFMDC. There has been a significant trend noted in the nature of inquiries during the past year. In particular, it has been noted that inquiries are becoming more specific and are concerned with more complex and difficult machining situations. Part of this trend is attributed to the wide distribution of the extensive amount of starting recommendations in the data products made available to the AFMDC User File. Also, prior Users have found by inquiry contact with experienced AFMDC Machining Data Analysts that capability exists to help solve complex machining problems.

The inquirer profile has also been relatively changing. A higher percentage of inquiries are being received at AFMDC from lower echelon personnel such as manufacturing or tool engineers, industrial engineers and time standards personnel, process engineers, tool designers, shop supervisors and foreman, planners, estimators, etc. This indicates that AFMDC is reaching and setting up a direct line of communication with not only management, but also with an increasing number of persons directly responsible for application of machining data and information available from AFMDC.

Summary of Specific Inquiries by SIC Number
(Figure 16, pages 20 through 22)

An analysis of inquiries by type of industry utilizing the services of AFMDC is given in Figure 16. The chart presents the inquiries by the SIC Code, a number which references listings in the Standard Industrial Classification Manual, Executive Office of the President, Bureau of the Budget, 1957, and Supplement to the 1957 Edition Standard Industrial Classification Manual, 1963. It should be noted that while the SIC codes are quite excellent, some descriptions should be modified to include important new industries. At the present time, interpretations are made by AFMDC for certain categories such as 3721-Aircraft & Missiles, 3722-Aircraft Engine & Engine Parts to include appropriate rocket and missile vehicles and engines. Also, some SIC descriptions may appear completely commercial, and yet an analysis of specific inquiries will indicate a close relationship to DoD requirements, as shown in Figure 17.

Government Agencies and Services Supported Directly and
Indirectly by AFMDC Inquiries (Figure 17, page 23)

The data shown in this chart are somewhat difficult to compile but by careful analysis of particular inquiries and by an analysis of the prime objectives of principal contractors at various plant locations it has been possible to show that the majority of requests made to the Center was stimulated by Air Force, AEC, U.S. Navy, NASA, and U.S. Army projects. Nontechnical inquiries, as indicated in Figure 17, are those which pertain to administrative arrangements and to visits where no machinability data or information as such was requested and none was given. An analysis of individual inquiries in categories 4 and 5 of Figure 15 has shown that most of these visits and inquiries concerning potential use of AFMDC relate directly to specific technical needs, and therefore cannot be regarded as nontechnical in nature.

Visitors to AFMDC are provided with literature pertaining to AFMDC services and operation and they are asked to inform others in their organization and encourage use of the Center.

Summary of Specific Inquiries by All Companies and Agencies
(Figure 18, pages 24 through 28)

This chart presents a total of 605 individual companies and divisions which are represented as inquirers of AFMDC. This is a comprehensive list. The chart also includes a summary of those companies making four or more requests. This list reflects high interest in AFMDC information on the part of aerospace industry, as represented by companies such as Aerojet-General Corporation, The Boeing Company, Curtiss-Wright Corporation, General Dynamics Corporation, General Electric Company, North American Aviation, TRW Inc., Martin Company, Grumman Aircraft, Lockheed Aircraft Corporation, and in fact Wright-Patterson Air Force Base itself.

Data Products Photo (Figure 19, page 29)
Typical Formats for Data Presentation (Figure 20, page 30)
Titanium Booklet Photo (Figure 21, page 31)

Planned data products have proven to be important output to AFMDC Users. In addition to providing valuable and timely data, these products serve as a direct line of communication with the Users of the Center. Excellent response has been received for the ten data products prepared and issued in 1966. These products are shown in the photo in Figure 19, and the formats are displayed in Figures 20 and 21. Careful thought was given to the preparation of the products to present the machining recommendations in complete but concise form in order to make easy and effective use of them.

Two separate data product announcements were prepared and sent to the User File which now consists of 3,574 individual names. The policy followed was to provide one free copy to Users who submitted a request and then charge for additional copies. The set limit of making 1000 free copies available proved to be practical inasmuch as all requests from the User File were able to be filled. The fine response for data products is indicated in Figure 26, page 38. A total of 12,150 copies were distributed, most of which were to the User File and some as direct response to inquiries. The 1,556 copies sold are further evidence of the high interest and use of the data products.

Data Acquisition Study (Figure 22, page 32)

For purposes of simplification, the study was divided into two parts, 1) U.S. literature, and 2) English language (excluding U.S.) literature.

U.S. Literature - It was found that AFMDC did not cover directly a total of 16 sources which were covered by the combined four services studied. Of 16 U.S. sources, only 21 articles pertaining to machining were identified over a six month period. Based on title and past experience, none of the sources appear significant to AFMDC. Sources such as Tool & Manufacturing Engineer, American Machinist, and Metals Progress each yield on the average of 4 articles per month whereas from the 16 sources not covered the average yield would be .0.25 articles per month. With regard to non-periodical U.S. literature, none of the four services have indicated that they cover the non-periodical literature to any degree. Of the 76 non-periodical references (in all languages) 37 of these were from ASTM conferences and picked up by Source No. 1, and 18 SAE conference papers were picked up by Source No. 3. Metalworking conferences in the U.S. are covered by AFMDC personnel and all of the significant papers are processed by AFMDC. It was concluded that none of the 4 services studied should be considered for input into AFMDC.

English Language Literature - The service considered the best British indexing service which concentrates solely on British literature was selected for this part of the study. All 4 services checked cover a total of 33 English language periodicals other than U.S. AFMDC is presently covering 31 of these sources by direct subscription as well as 16 other sources not covered by any of the 4 services.

There were 52 sources listed which are not covered by AFMDC, 31 of which are covered by the British service. The 31 sources listed showed only 4 sources which were considered for direct acquisition by AFMDC, as follows:

1. Engineer (U.K.) - 5 articles for 6 months
2. Tooling (U.K.) - 12 articles for 6 months

3. Process Control & Automation - 4 articles for 6 months
4. Light Production Engineering - 4 articles for 6 months

The remaining 27 sources covered by British service yielded only 45 references for the 6 month period or only an average of 0.3 articles per month per periodical. The other 3 services showed 16 additional sources. Fifteen of the 31 sources were common with the British service. None of the 16 journals had more than 3 references for the 6 month period and the total for the 16 sources was 26, which is an average of 0.26 articles per month per periodical.

General Conclusions - Using the study as a basis, the 43 sources (16 U.S., 27 British) not covered by AFMDC would yield only 117 documents annually which breaks down to about 0.25 articles per source per month in contrast to AFMDC source production of 1.3 articles per source per month. This results in 12 documents per month of unknown value to 200 periodical documents per month of known value presently evaluated by AFMDC. Based on this analysis, we are evaluating 94% of English language periodical literature covering material removal.

It was concluded that with the exception of the 4 British sources listed, AFMDC is adequately covering the volume of all English language periodical literature pertinent to material removal.

Data Acquisition Plant Visit Program, (page 33)

The information contained in page 33 covering this program is self-explanatory. An expansion of this type of data acquisition effort is planned for 1967 in view of the interest on the part of industry, the high yield of important data, and the contact with personnel resulting in an increase in specific inquiries.

Code Sheet for Project Time Card (Figure 23, page 34)

The code sheet provides the basic approach to AFMDC System costing. Approximately 120 individual time codes are in current use. It has been simple for individuals to maintain time records because relatively few time codes are used by any one person during a given day and the use of the same codes is repeated from day to day.

Figures 24 and 25, shown on pages 36 and 37, reflect the use made of project time card data. Records are available for making even more detailed analyses if required. For example, it would be possible to analyze the costs for serving particular companies during given periods.

[illegible]

AFMDC Data Products (Figure 2b, page 38)

A-10

the progress made by AFMDC during the past year. For the period of February 1, 1966 through January 31, 1967 the input costs represented 45.5% of the total operating costs. By contrast, for the period of October 1, 1964 through January 31, 1966 this percentage was 66%. This increased efficiency was gained through working experience and putting into operation the IBM 1130 Computing System. As a result it was possible to expend considerably more effort on output functions. Output costs for the past year were 41% of the total effort as compared to 20% for the previous 16-month period. Answering of inquiries represented the major portion of the output costs. A total of 736 inquiries were processed over the 12-month period for an average of approximately 61 per month. The average was 37 per month for the 595 inquiries in the previous 16-month period. The second major output expenditure was toward the preparation of ten data products. Additional details pertaining to the content, cost of preparation and distribution of each of the products are presented in Figure 26, page 38. The percentage of operating costs for systems analysis, modification and control was 13.5%, a slight decrease from 14% for the 16-month period. About two-thirds of the effort was expended in connection with setting up and making operational the IBM 1130 Computing System.

One of the important control functions is the Operations Manual and Detailed Code Book development and updating. The Operations Manual outlines all the detailed procedures for Center operation and is kept up to date by the Director of the Center. The Detailed Code Book is also continually updated by the Director. These two manuals constitute management aids for supervision of the Center's operation and are supplied as required to individual AFMDC personnel. System reports, such as Monthly, Quarterly and Annual Reports plus special reports for sponsors and meetings, also develop significant costs.

Future Planning (page 39)

One of the major goals of 1967 is to effect a direct line of communication between more manufacturing engineers who need data and the engineer at AFMDC. The methods used to accomplish this are outlined under Future Planning, page 39. The User File at the present time consists of 3,574 persons who have received copies of User File Announcements #1 and #2. Many of these persons are inquirers or have received one or more data products and by these services are aware of the type of information available. It is planned to make available to Users a list of the type of materials, machining operations and keywords covering AFMDC's broad scope. Awareness of the scope should stimulate inquiry activity from the Center's potential Users. Plans also include a program whereby a User may initiate an inquiry on a specific machining situation and be kept up-to-date on a monthly basis on new information entered into the AFMDC data bank.

Technological changes in manufacturing techniques and materials should be reflected in the acquisition requirements of AFMDC. Effort will be expended to enhance the program AFMDC uses to evaluate inquiries in light of industrial requirements. With this program, AFMDC is able to direct acquisition effort into those areas where information is lacking.

The program of plant visitation will be continued with increased emphasis on making the industrial User aware of the information at AFMDC which is available to him.

Effort on data products will be directed toward preparation of the three products listed under Future Planning since information seems to be lacking or widely scattered on these subjects. Additional data products will be prepared as good timely information is accrued by AFMDC.

ECONOMIC ENVIRONMENT FOR AFMDC OPERATIONS

(Annual Costs)

Labor and Overhead Costs for Operating Metal Cutting Machine Tools in the Metalworking Industries in the United States

Total number of metal cutting machine tools in the metalworking industries (June 10, 1963, American Machinist Inventory of Metalworking Equipment) = 2,137,497

Average labor cost + overhead = \$8.00 per hour

Average working day = 8 hours

Number of working days per year = 250

Average number of direct labor personnel per machine = 1

Total Cost of Labor + Overhead:

$2,137,497 \times \$8.00 \times 8 \times 250 \times 1 = \$34,199,952,000$ or about

\$34,000,000,000

Based on the 1963 Inventory and actual 1964 and 1965 metal cutting machine tool shipments, American Machinist estimates that 2,500,000 machine tools were in use at the end of 1965. Using this projection, the \$34,000,000,000 would be revised to \$40,000,000,000.

Total Cost of Labor + Overhead:

$2,500,000 \times \$8.00 \times 8 \times 250 \times 1 = \$40,000,000,000$

\$40,000,000,000

Total Shipments Including Exports of Metal Cutting Type Metalworking Machinery

\$1,040,766,000 (1965)

Source: U. S. Department of Commerce

Machine Tool Accessories Industry

\$971,000,000

(including small cutting tools for machine tools and metalworking machinery in the amount of \$598,000,000)

Source: 1965 Census of Manufacturers
Bureau of Census

Cutting Fluids

\$35,000,000

Source: "Coolant Control... a plant study plan" by B. F. Wilson, Automatic Machining, June 1965.

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13. ABSTRACT This is the Second Annual Report of the Air Force Machinability Data Center covering the period February 1, 1966 through January 31, 1967 (Contract AF 33(615)-5262). Eight thousand eight hundred and sixty (8,860) documents were processed and 46,428 machining situations were evaluated and placed in data storage. Seven hundred thirty-six (736) specific inquiries were answered for 396 different companies in 90 different SIC categories. Thirteen thousand seven hundred and six (13,706) copies of 11 different data products were distributed during this period. The average cost of inquiries equalled \$45.02 per inquiry. An IBM 1130 computer system was installed and made available to AFMDC on July 1, 1966. Computer programs were written to store, update and search the files necessary to operate the Center.		

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Machining						
Management						
Data Center						
Information Center Costs						
Information Center Economics						
Computer Data Processing						
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